Olin - Sp Olin

TXD000607028

A REPORT ON THE ASSESSMENT OF SOIL CONTAMINATION IN OLIN SITE

OLIN CORP. - S P OLIN
TXD000607028

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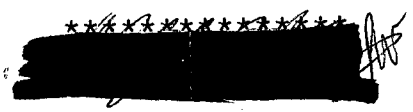

TABLE OF CONTENTS

PAGE

Error of Citation: rather than waiver, C.B.I. claim was "determined" invalid, in accordance with 40 C.F.R. §2.205(f). See 60RC Ltr to Womble, Novbr-17-1983. - P.M.W. (6C-G) Nov86

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INTRODUCTION

This report presents the assessment of soil contamination in the Olin Company facility at 7621 Wallisville Road, Houston, Texas as of June, 1982. The report describes the methods and materials used to provide unbiased data sources upon which the assessment was based. The assessment utilizes 3 data sources: (1) the chemical analysis of soil samples taken at the Olin site and check sites, (2) a SYMAP projection of the concentration - areal distribution of specific soil toxicant over the Olin and check sites, and (3) the estimated concentration of soil toxicants in soil solution based on equilbrium constants of the toxicants and their concentrations in the soil samples.

The following individuals and organization contributed their talents and resources to this project:

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- [J.L.T. (6C-H) Dec83] -

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List of Tables

and experimentally derived K values.

13. Estimated equilbrium concentrations of DDT in ambient soil solution of upper soil cores in Olin and check site calculated from concentration value of soil samples exceeding 1 ppm DDT and experimentally derived K values.

14. Estimated equilbrium concentrations of Dieldrin in ambient soil solution of upper soil cores in Olin and check site calculated from concentration values of soil samples exceeding 1 ppm Dieldrin and experimentally derived K values.

15. Estimated equilbrium concentration of Chlordane in ambient soil solution of upper soil cores in Olin and check site calculated from concentration values of soil samples exceeding 1 ppm Chlordane and experimentally derived K values.

16. Estimated equilbrium concentrations of Hexachlorobenzene in ambient soil solution of upper soil cores in Olin and check site calculated from concentration value of soil samples exceeding 1 ppm Hexachlorobenzene and experimentally derived K values.

17. Estimated equilbrium concentrations of Biphenyl (PCB) in ambient soil solution of upper soil cores in Olin and check site calculated from concentration values of soil samples exceeding 1 ppm Biphenyl and experimentally derived K values.

18. Estimated concentration of Hexachlorocyclohexane in ambient soil solution of upper soil cores in Olin and check site calculated from concentration values of soil samples exceeding 1 ppm Hexachlorocyclohexane and experimentally derived K values.

19. Comparison of select toxicant concentrations in ambient soil solutions in Olin and check sites of soil samples con - centrations exceeding 1 ppm of respective toxicant.

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- [J.L.T. (6C-H) Dec82] -
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List of Figures

16. SYMAP for PCB
17. SYMAP for Chlordane
18. SYMAP for Dieldrin
19. SYMAP for Hexachlorocyclohexane
20. SYMAP for Total toxicants

C.B.I. CLAIM WAS WAIVED
- 40 C.F.R. §2.205(d)(1) -
- [J.L.T. (6C-H) Dec82] -
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Section I - Acquisition of soil samples

1.1 Soil sampling plan - A soil sampling plan designates in an unbiased and random manner which units (soil samples) of the population (soil in Olin and check sites) are taken as representative of that population. The plan employed in the Olin site survey was a systematic sample plan involving a random sampling of soil from selected units spaced at regular distances along 2 dimensions in a grid design where the intersection of the grid lines identify the unit locations.(1) (see map of Olin site, Figure 1). This design provided an umbiased, efficient and rigorous sampling of the site at minimum cost.(1) Because greater soil contamination was suspected in the northern portion of the site, the sample locations were spaced closer providing more observations per unit area than the southern part where less soil adulteration was suspected. Included in the systematic plan were 2 judgement samples(1) to measure toxicant load in soil of areas surmised as waste dump areas.(4)

Two check sites were located in a residential area approximately 2000 M from the Olin site within an environment similar to the Olin site with respect to industrial activity, particulate fallout and/or aerosol dispersants, and soil series (Lake Charles Clay)(5) Fig. 2. The latter parameter is particularily important because soil properties profoundly influence the retention of organic toxicants. The check sites were uninhabited, thickly weeded, residental lots which apparently had not been used for gardening, recreation, or as a homestead since the area was settled (since 1940). The sample locations in the check site were judgement samples sited in an area of level terrain and typical

soil (Lake Charles) profile based on a preliminary examination.

The number of sample units (N) over the Olin site was estimated from the relationship, $N=4\ s^2/L^2$ where s^2 is the population variance, L^2 is an acceptable variance selected for our survey, and N is the number of samples.(2) From a preliminary report by EPA concerning soil contamination at the Olin site(3), it was determined that only 12 samples of soil were analysed for DDT. The mean concentration of DDT was 4357 ppm with a standard deviation of 1000 ppm. Since these were the only data available for the 12 samples, they were utilized as the values measuring the DDT distribution in the population (The Olin Site). For our study we assigned a limit of 500 ppm as a generic standard deviation for the toxicants we were to measure ($500^2=L^2$). Substituting these values into the above equation provided a benchmark N of 16-20 samples for the site. Therefore, for this survey, 23 random soil samples locations were assigned to the Olin site including the judgement samples and 2 samples to the check sites, 1 sample from each of the 2 check sites (Fig. 2).

(1) Peterson, R.G. and Calvin, Z.D. 1976. Sampling, In Methods of Analysis. Part I. No. 9 Agronomy Series. American Society of Agronomy, Madison, Wis., U.S.A.

(2) Snedacor, G.W. and Cackran, W.C., 1982. Statistical Methods 7th Edition, Iowa State University Press, Arnes, Iowa, U.S.A.

(3) E.P.A. January 19, 1981. Code PVL. Letter to S. Pacific Transporation Company c/o Mr. H.B. La Tourettee, General Attorney, 913 Franklin Ave., Houston, Texas 77002

(4) E.P.A., 1982. Photographic Analysis of the Olin Hazardous Waste Site on Wallisville Road, Houston, Texas pp. 11-14.

(5) Soil survey of Harris County and Harris County Flood Control District, U.S.D.A. and Soil Conservation Survey, Temple, Texas.

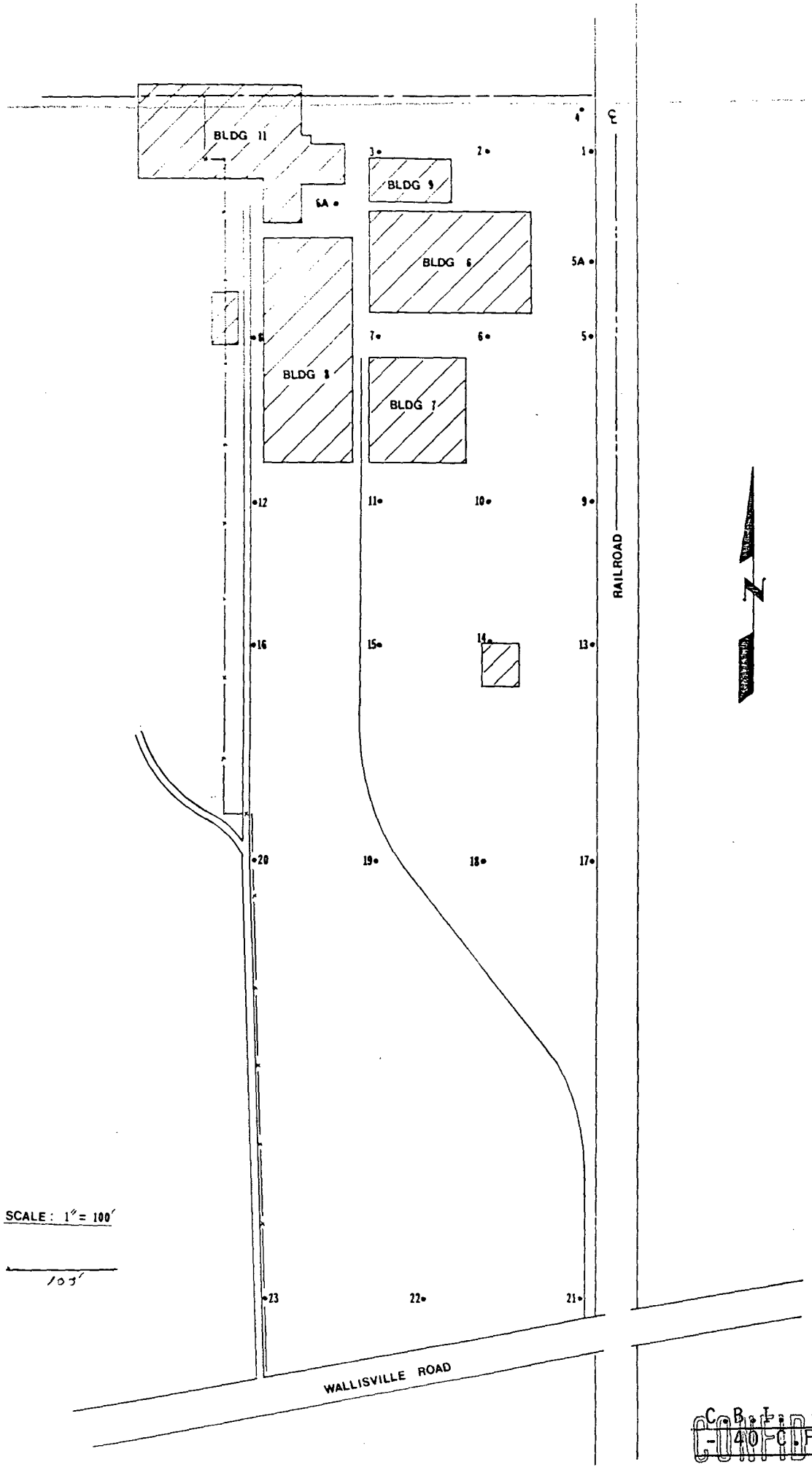
Section 1.2 - Soil sample core collection and sample preparation - methods and materials

Preparation

The sample sites were located using the N. E. corner fence post as the base point, measuring along the E. fence to the S. E. corner of the property with a flexible steel tape to fix the location of the grid lines according to the design shown on the chart (Fig. 1). The grid lines were delineated in the field by affixing bright colored plastic flag strips to the E. fence. The same procedure was followed along the W. fence beginning at the junction of the W. and N. fences moving to the S. W. end of the property. The intermediate sample points along the respective grid lines were located by measuring the prescribed distances along the grid lines using the plastic flag marker on the W. and E. fences to align the intermediate sites which were then marked by red-ribboned nails struck into the asphalt-concrete surface.

A truck-mounted hydraulic screw auger (4" diameter) and shelby-tube core sampler 3" diameter-24" long housing (Soil Engineering, Inc.) was driven to the respective sample sites to obtain the soil core samples. The steel screw auger was used to penetrate the asphalt-concrete paved surface and the overburden (fill). The fill was piled away from the auger hole and excess material cleaned from the boring by hand (using rubber-composition gloves). When the soil surface was reached, the auger was removed and the shelby-tube attached to the hydraulic press. The corer was pushed to a depth of 24 inches, lifted from the hole and the soil core removed from the tube by means of a pressure piston rod. The soil core was cut crossectionally with a steel knife into 2 parts and the fresh surfaces immediately examined

for the following parameters: color, texture, odor, presence of foreign material (debris), soil type and horizon differentiation. An estimation of soil moisture was also made. The shelby-tube was cleaned by wiping the inside surface with a clean cloth and a second, deeper soil core was taken from 24" to 48" depth and examined as described above. The auger and corer were wiped clean before the next site was sampled. Each core was wrapped in aluminum foil to preserve moisture and volatile agents. The wrapped core was placed into a plastic zip bag, labeled as to site, depth, date, and name of investigator and placed in a cardboard container under a canopy in the rear of a pick-up vehicle. The samples were transported that day to a deep freeze holder at College Station, Texas. The surfaces of the soil cores were not scraped of removed in the field. We felt that this would induce contamination. Instead, the cores were prepared in the laboratory by W. K. Brown Assoc. and packed into sterile glass jars prior to sending them to the analytical laboratory.



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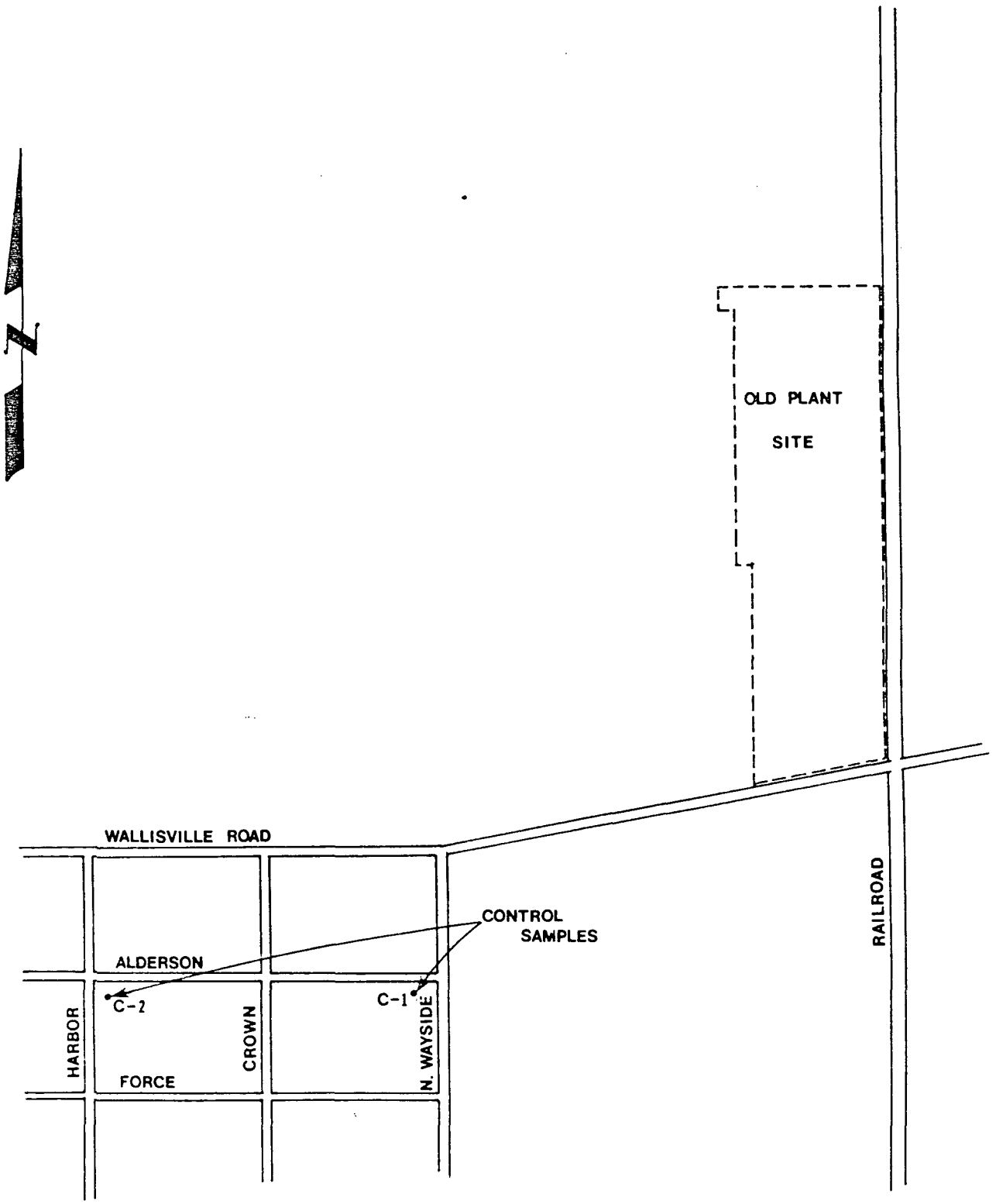

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Section 1.3 - Field description of soil sample cores

Descriptions of the fresh soil sample cores were made at the Olin and check sites for the following parameters:

1. Color
2. Soil series
3. Horizon differentiation
4. Odor
5. Texture
6. Debris

The description of the cores are given in Table 1 and delineated on the map of the Olin and check sites in Figure 1 and 2. Sample site is identified in the Table and map by the appropriate number. Soil depth is designated in the Table as (1) a sample core taken just under the fill to a depth of 24" (60 cm) or shallow depth. The number (2) identifies a sample core taken from 24" to 48" (120 cm) or deep depth.

Table 1 - Field descriptions of soil sample cores

Sample site	depth	description
1	1	0"-15" fill, sand, gravel, 15"-24" core, grey blk., poor horizon, sulfur granules, Lake Charles Series. (L.C.)
	2	24"-40" grey blk, much debris, shell slight to strong odor, L. C., clay, shell mix.
2	1	0"-18" fill, black powder, shell, L. C., poor hor. strong odor, 18"-24" core sample L. C., glass mix, clay, sulfur particles, shell, glass, strong odor, no hor., some clay.

sample site	depth	description
	2	24"-218"much debris, no hor., very strong odor, clay grey blk, shell.
	3	48"-60" L. C. strong odor, much debris, fair hor., clay.
	4	60"-84", L. C. good hor. some debris, sl. odor, clay.
3	1	0"-19" fill, 19"-24" core, lime fill, sulfur granules, strong odor, poor hor.
	2	24"-28" lime, sulfur streak, sl. odor, fair hor.
4	1	0"-16" fill, gravel, 16"-24" core, L. C. some debris, sulfur granules, strong odor, fair hor.
	2	24"-48", lime granules, clay, slight odoe, grey black, fair to good hor.
5	1	0"-12" fill, lime, sand, stone; 12"-24" sample, grey bl. some debris, L. C. slight (sl.) odor, clay.
	2	24"-48" gr. bl. L. C. poor horizon (hor.), much debris, strong odor, clay, rock.
6	1	0"-7" fill, sand, clay, shell: 7"-30" debris, foundation brick red, 30"-40" core sample, grey, black (gr. bl.) Lake Charles (L.C.), debris, strong odor, clay.
	2	48"-60" grey black (grey bl.), L. C. normal horizon, little debris, no odor, clay.
7	1	0"-12" fill, 12"-24" poor hor., L.C. mostly debris, no odor. Dark gr.
	2	24"-48" much debris, poor hor., very sl. odor, L. C. clay.

sample site	depth	description
8	1	0"-12" fill, lime, stone, 12"-24" debris, orange color, sulfur particles, no odor.
	2	24"-48" poor hor., debris mixed clay, slight odor, L. C. gr. bl.
9	1	0"-17" fill, strong odor from core hole, 17"-24" sulfur granules, some mottles, no odor of sample.
	2	24"-48" no debris, good hor. L. C. grey bl. no odor, clay.
10	1	0"-20" fill, 20"-36", poor hor., clay, L. C. some debris, sulfur granules, strong odor. Light gr.
	2	36"-48", some debris, L. C. strong odor clay, rock mix.
11	1	0"-22" fill, 22"-36" L. C. sulfur streaks, sl. odor, blk, debris.
	2	36"-48" no odor, L. C. blue-blk color.
12	1	0"-22" fill, 22"-36" poor hor., debris, sulfur particles slight-strong odor, L. C. clay.
	2	36"-48", L. C. clay, no odor, good hor.
13	1	0"-15" fill, assorted materials, 15"-24" strong odor, L. C. clay, grey bl. some mottles.
	2	24"-48", L. C. mottles, slight odor.
14	1	0"-18" fill, 18"-24" core sample, poor hor. debris, black color, grit strong odor.
	2	24"-48" poor hor., clay debris is clay,

sample site	depth	description
		mix, black grit soot-like, sligh odor.
15	1	0"-36" deep fill, clay, rock, lime, shell. no hor. possible ditch site or railsite.
site is highest level of area		
	2	36"-44", no odor, no hor., debris, clay mix.
	3	44"-56" some debris, L. C. grey bl., no odor to sl. odor.
16	1	0"-12" fill, 12"-24" sample core, light grey bl. slight odor, clay.
	2	24"-48" debris, gravel, shell, L. C. sl. odor.
17	1	0"-10" fill, 10"-24", L. C. slight odor, small debris, grey bl. clay.
	2	24"-48", L. C. clay, no debris, slight odor.
18	1	0"-11" fill, sand black grit, 11"-24" core black, gritty, poor hor. slight odor.
	2	24"-48", poor hor. glassy, gritty material black no odor, L. C.
19	1	0"-24" fill, 24"-48" core sample, debris, grit, shell, poor hor. L. C. much stone, and organic matter, slight odor; Little clay.
	2	48"-72", L. C. good hor. clay, grey bl., slight odor.
20	1	0"-11" fill, 11"-24" sample core, L. C., no odor, clay sand mix.
	2	24"-48", L. C. some debris, gravel, slight odor, clay.

sample site	depth	description
21	1	0"-16" fill, 16"-024" core sample, L. C. good hor. no debris, no odor, some lime streaks, clay.
	2	24"-48", L. C. good hor. no debris, no odor, clay.
22	1	0"-12" fill, 12"-24" sample L. C., some lime; clay, no odor, good hor.
	2	24"-48", L. C. grey bl., no odor, clay, nor debris.
23	1	0"-10" fill, sand, gravel, 10"-24", L. C. grey bl. no debris, clay, no odor.
	2	24"-48", L. C. good hor., no odor, gr. bl, clay.
5A	1	0"-12" fill, 12"-24" very strong odor. L. C. poor hor. much debris, sulfur streaks.
	2	24"-48" very strong odor, L. C. very bl. No debris, fair hor.
6A	1	0"-18" fill, 18"-24" L. C., poor hor. debris-strong odor grey bl., clay, shell.
	2	24"-48" L. C. little debris, grey bl. clay, strong odor.

Check site	depth	description
C1	1	0" fill, 9"-24", core, L. C., typical hor., no debris, earthy, fresh odor, grey bl., clay.
	2	24"-48", L. C. fresh earthy odor, clay no mottling. Site on lot, corner of E. Wallis-field and Exchange, 500 ft. S. on Exchange.

Check site	depth	description
C2	1	0" fill, 8"-24", L. C., some stone, no odor, clay gr. bl., typical hor.
	2	24"-48" L. C., no debris, excellent hor. clay, earthly, fresh odor. Site on lot, corner of Harbor and Aldson.

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Section 2 - CORE HANDLING AND SUBSAMPLE PROCEDURES - This part of Section 2 of this report written and submitted by K.W. Brown and Associates, Inc., 707 Texas Avenue S., Suite 202D, College Station, Texas 77801

2.1 Introduction and Objectives

Personnel at K. W. Brown and Associates, Inc. (KWB) were contacted on May 27, 1982, by Dr. Eugene Brams of Pollution Assessors regarding a former industrial site which was potentially polluted with residues from the formulation of chlorinated pesticides. KWB agreed to assist in a sampling program at the site to assess the degree of pollution, if any, of soils and surface fill and debris. Preliminary actions included a visit to the site by Mr. Gordon Evans of KWB, the project supervisor, discussions with Dr. Brams concerning sampling strategy, and acquisition and review of historic data (i.e. sample analyses and aerial photos). A sampling plan specifying sample locations was developed by Dr. Brams in consultation with Mr. Evans, and KWB scheduled a contractor to provide the soil coring equipment and technicians. Mr. Evans arrived at the site a second time on June 21, and assisted Dr. Brams and the soil coring contractor in obtaining samples from the locations designated in the sampling plan. The following is a description of procedures employed by KWB in packaging, transporting, subsampling and delivering the soil core samples.

2.2 Chain of Custody Procedures

A sample security, identification and tracking system was used to assure positive sample identification and to prevent knowing or unknowing tampering by outside parties. In the field, sample bags were each assigned a sample code number using an indelible marker. Two seals were then placed on each "zip-lock" sample bag such that samples could not be removed without breaking one or both seals. A chain-of-custody form (sample form attached) was completed and signed by Mr. Evans, and all samples remained in his custody until they were relinquished to the Texas A & M University Chemistry Department laboratory for analysis.

2.3 Sample Transportation and Storage

After packaging core samples in the field, boxes containing the sample bags were immediately transported by truck to College Station, Texas. During sampling and transport, core samples remained at ambient temperatures, approximately $30^{o}C$. Sampling time was approximately seven hours while transport to College Station required two hours. Minimal losses of the compounds of concern would occur at this ambient temperature in such a short duration since these compounds are persistent in the environment, with compound half-lives in soil on the order of months or years. Upon arrival at KWB facilities, the samples were placed in cold storage at less than $0^{o}C$ while awaiting subsampling.

2.4 Subsampling Protocol

Preparation of samples before delivery to the laboratory was necessary to avoid cross-contamination of samples as well as to provide a practically manageable quantity for analysis. Subsampling also provided a practically manageable quantity for analysis. Subsampling also provided material reserves in the event that additional testing was to

be needed or if the laboratory's samples were lost or damaged. The subsampling protocol was as follows:

(1) Samples were removed from cold storage and carried to KWB laboratories for preparation

(2) Work table was cleaned and covered with a layer of heavy-duty aluminum foil to provide a clean working surface

(3) Technicians were outfitted with rubber gloves for personal safety

(4) Sample bags were arranged in order from least to most contaminated, as judged by Mr. Evans based on field observations and aerial photo interpretations

(5) Bags were opened only as needed to prevent accidental intermingling which could result in erroneous sample labeling

(6) Likewise, subsample jars were labeled only as needed

(7) As each core was removed from its bag, the aluminum foil wrap was unrolled from the core and spread to provide an individual work surface (if cores were handled directly on the table, sample cross-contamination could occur)

(8) The exterior of the cores were trimmed, exposing the interior portion which had not contacted the metal shelby tube used in the field to obtain the samples (see Figure 1). Stainless steel knives were used to trim and subsample. These knives were prewashed in tap water followed by rinsing in chromatographic grade acetone (acetone, an organic solvent, dissolves and removes traces of the organic chemicals of concern). One of two methods of trimming was used (Figure 1a or b) dependent on the texture of the given core. Plastic, clayey

cores were trimmed by method "a", while hard crumbly cores or those containing large debris were trimmed by method "b".

(9) Subsamples consisted of lengthwise slices or wedges of pretrimmed cores to provide a proportional sample from the entire core length (see Figure 2). Method "a" or "b" was used for each core which had been pretrimmed according to method "a" or "b" in Figure 1, respectively. A subsample of about 250 grams mass was separated out of each approximately 2000 gram core.

(10) Subsamples were placed in prewashed and labeled screw-cap glass jars which were supplied by the TAMU chemistry laboratory doing the analysis. Aluminum foil cap liners were plaved over the jar mouth before the caps were placed on the jars.

(11) After subsampling, the remaining core material was repackaged in the orginal foil wrap and zip-lock bags.

(12) Subsampling was begun on the afternoon of 23 June 1982 and finished during the afternoon of 24 June. All samples and subsamples were kept in secure cold storage during the night of June 23, until resumption of work.

On the afternoon of 24 June, all samples and subsamples were transported by Mr. Evans to the TAMU chemistry laboratory. There he was met by Dr. Eliott Atlas, chemist in charge of analysis, and all materials were placed in cold storage. Mr. Evans then dated and initialed the chain-of-custody form and relinquished possession to Dr. Atlas, who in turn signed and dated the chain-of-custody form.

CHAIN OF CUSTODY RECORD

Sample Source (Company)_____

Sampler_____

Witness_____

Dates_____

Sample Type_____

Sample Numbers_____

Preservation Method_____

Analysis Required_____

Recipients:

	Company	Signature	Date Received	Date Released	Initials (Release)
1)					
2)					
3)					
4)					
5)					
6)					
7)					
8)					
9)					
10)					

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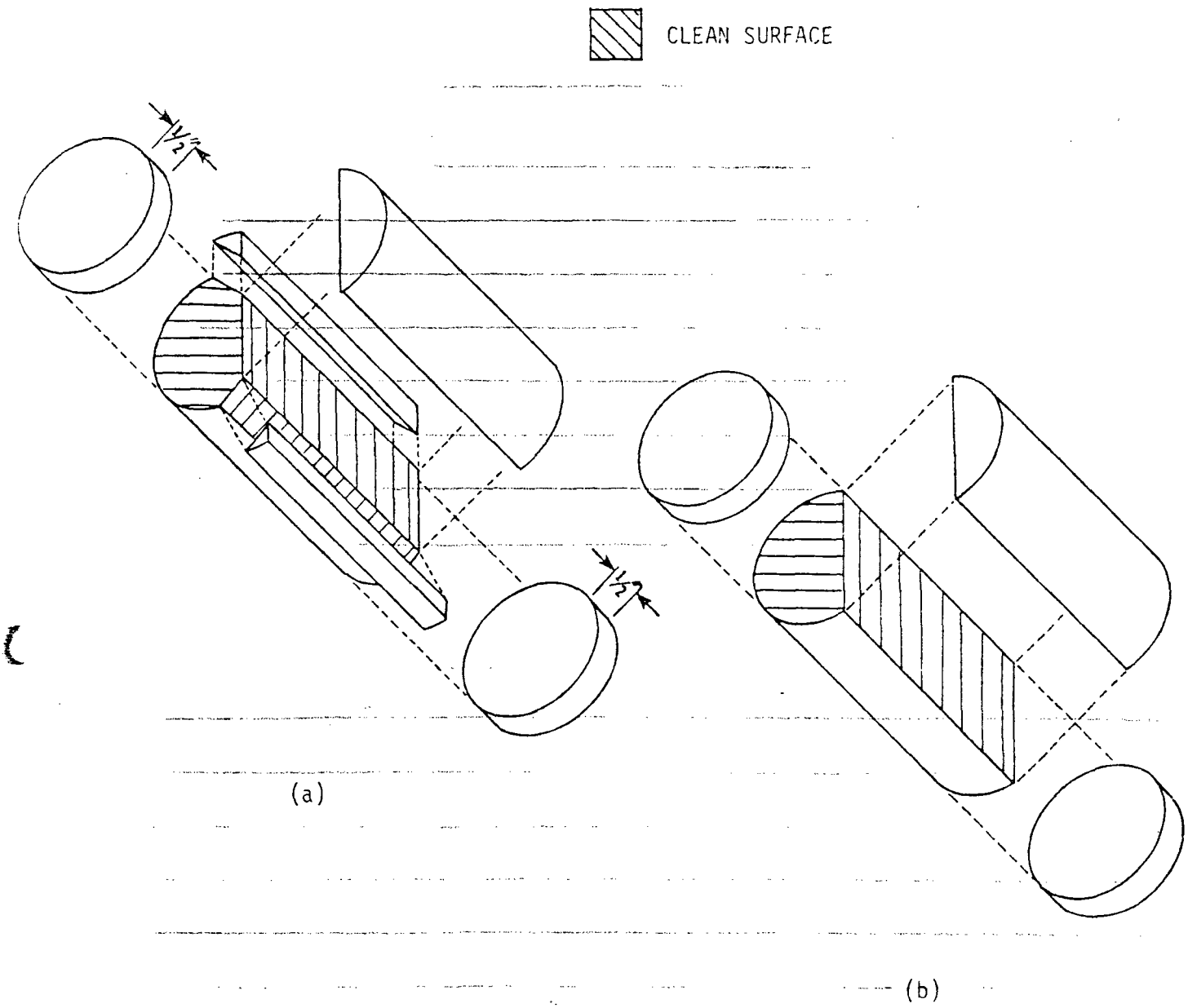

Figure 3 Methods used to trim core samples, (a) plastic, clayey cores and (b) hard, crumbly cores or those containing large debris or gravel.

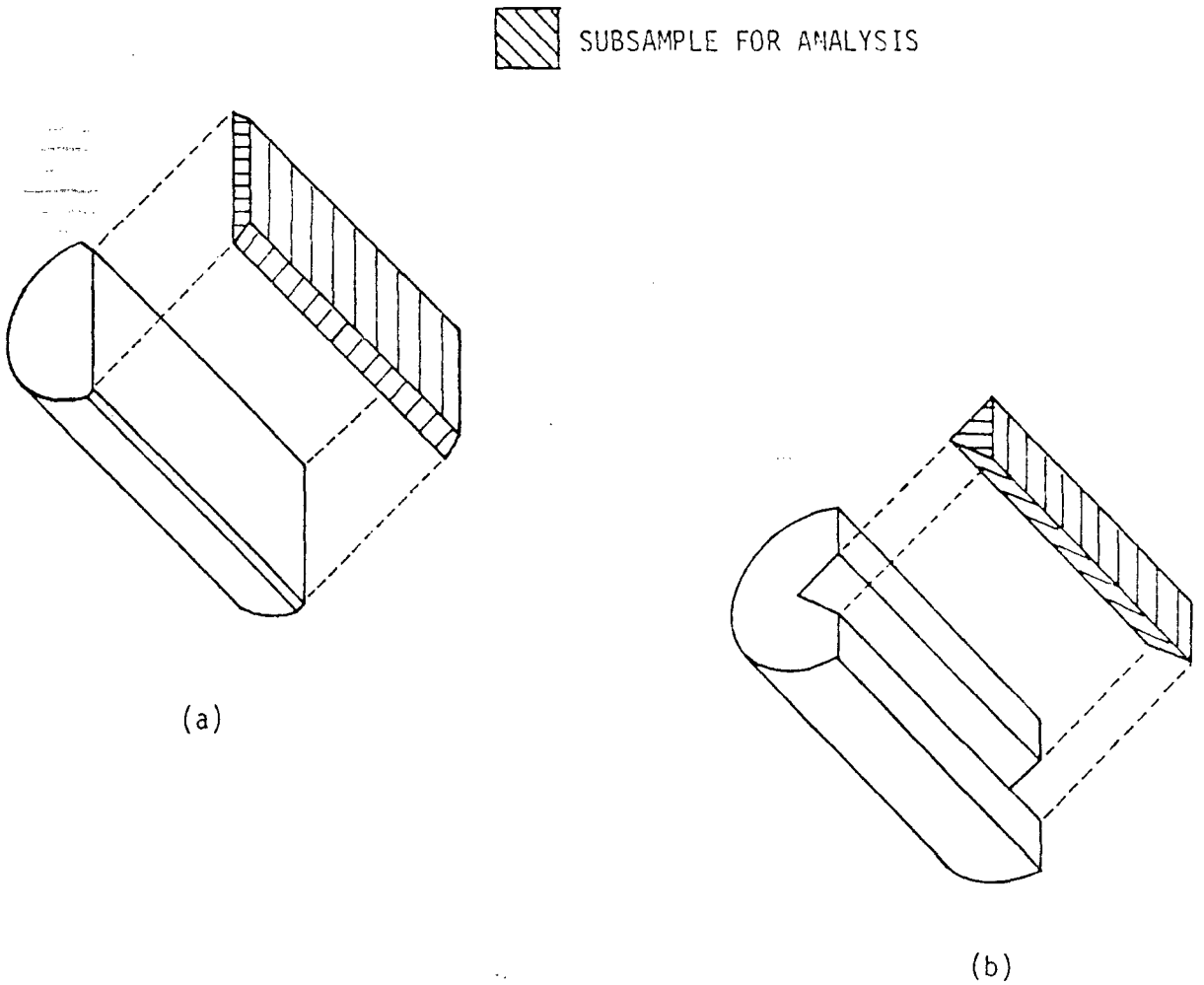

Figure 4 Methods used to subsample pretrimmed cores, (a) plastic, clayey cores and (b) hard, crumbly cores or those containing large debris or gravel.

Section 3 - Chemical analysis of soil samples - from a report prepared by Dr. E. Atlas in consultation with Dr. C. S. Giam, environmental Services, Dept. of Chemistry, Texas A & M University, College Station, Texas 77843.

This report describes the results of chemical analyses of soil samples from a site in Houston, Texas. The objective of the study was to determine the concentration of selected chlorinated hydrocarbons (e.g. pesticides) at the study site in Houston. Selected compounds include toxaphene and DDT (Figure 1), as well as HCB, HCH, chlordane and PCB.

Details of the methodology are presented in the technical section submitted in a separate report which is included in its entirety in the Appendix. The report by the organic chemists is an independent appraisal of soil contamination at the Olin site, known only to them as a Houston site. This assessment requested by the coordinator (Dr. Eugene Brams) and the attorney (Mr. Robert Maher) as substantative information to the coordinator assessment of the soil contamination at the Olin site. No other information was provided concerning the site other than required in the chain of custody form (See Section 2.2).

Briefly, soil samples collected at the site were subsampled and stored frozen until analysis. The organic compounds were extracted from the soil using suitable organic solvents. Separation of the complex mixture of compounds in the extract was carried out by absorption chromatography followed by capillary gas chromatography (GC). Examples of instrument (GC) responses to toxicants in soil extracts and standard concentrations in solvent of select toxicants are shown in the following representations of data printout recorder responses. In the printout,

(Figures 5, 7, 8, 9, and 11) the sample of a typical soil extract is identified by the soil sample number in the upper left corner. Included is the dilution factor required to reduce the concentration of the select toxicant in the extract to levels within the detectable range of the instrument. Examples of select standard recorder responses are given in Figures 6, 8, and 10. The response peaks to the standard toxicant can be compared to the peaks found in the soil sample extracts and identifies the toxicant. The peak area is used to calculate the concentration of the soil toxicant.

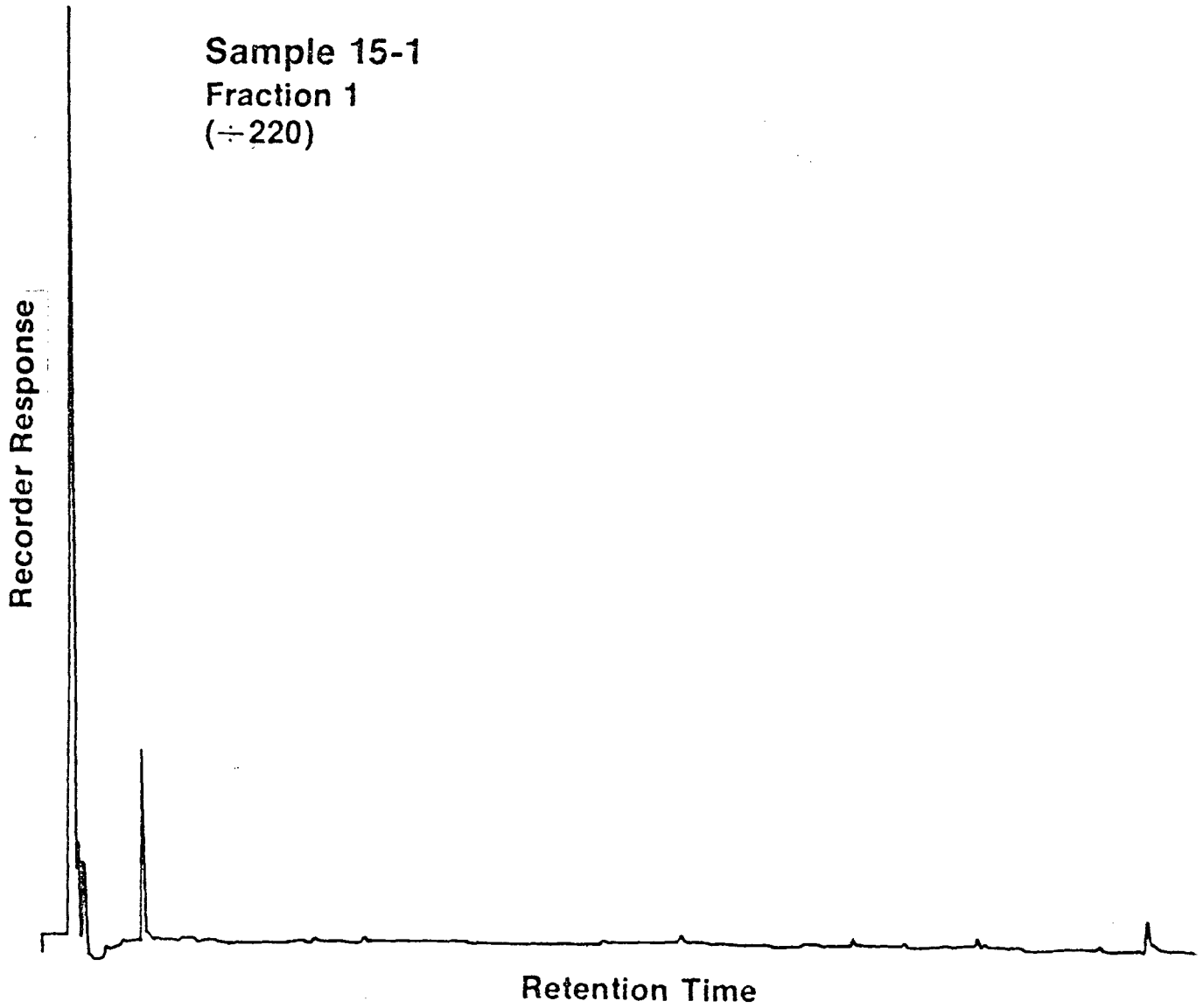

FIG. 5 GC COLUMN PRINT OF A TYPICAL SOIL SAMPLE EXTRACT CONTAINING VERY LOW CONCENTRATION OF TOXICANT

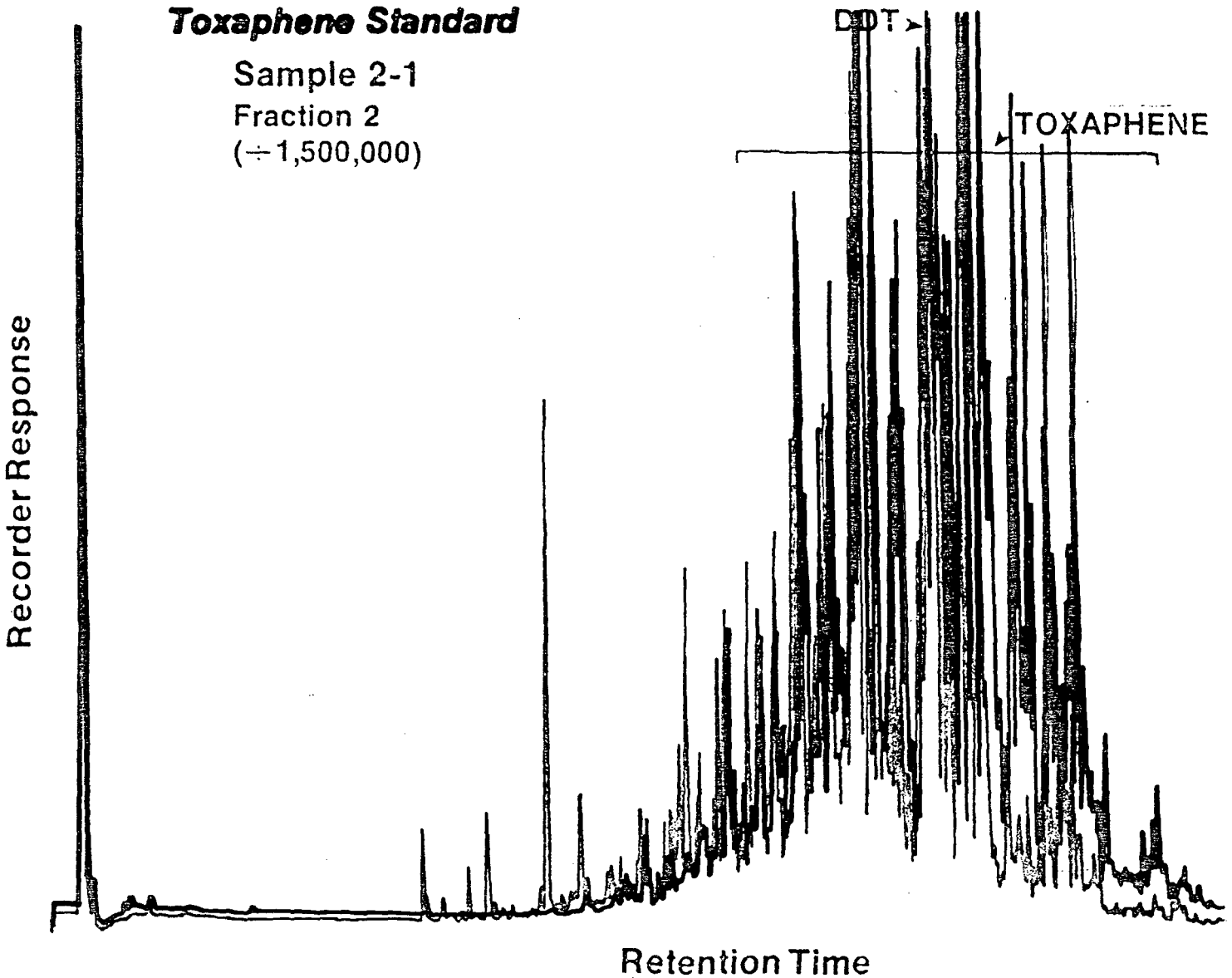

FIG. 6 GC COLUMN PRINT OF TOXAPHENE STANDARD

FIG. 7 GC COLUMN PRINT OF SOIL EXTRACT SHOWING TOXAPHENE AND DDT PEAKS

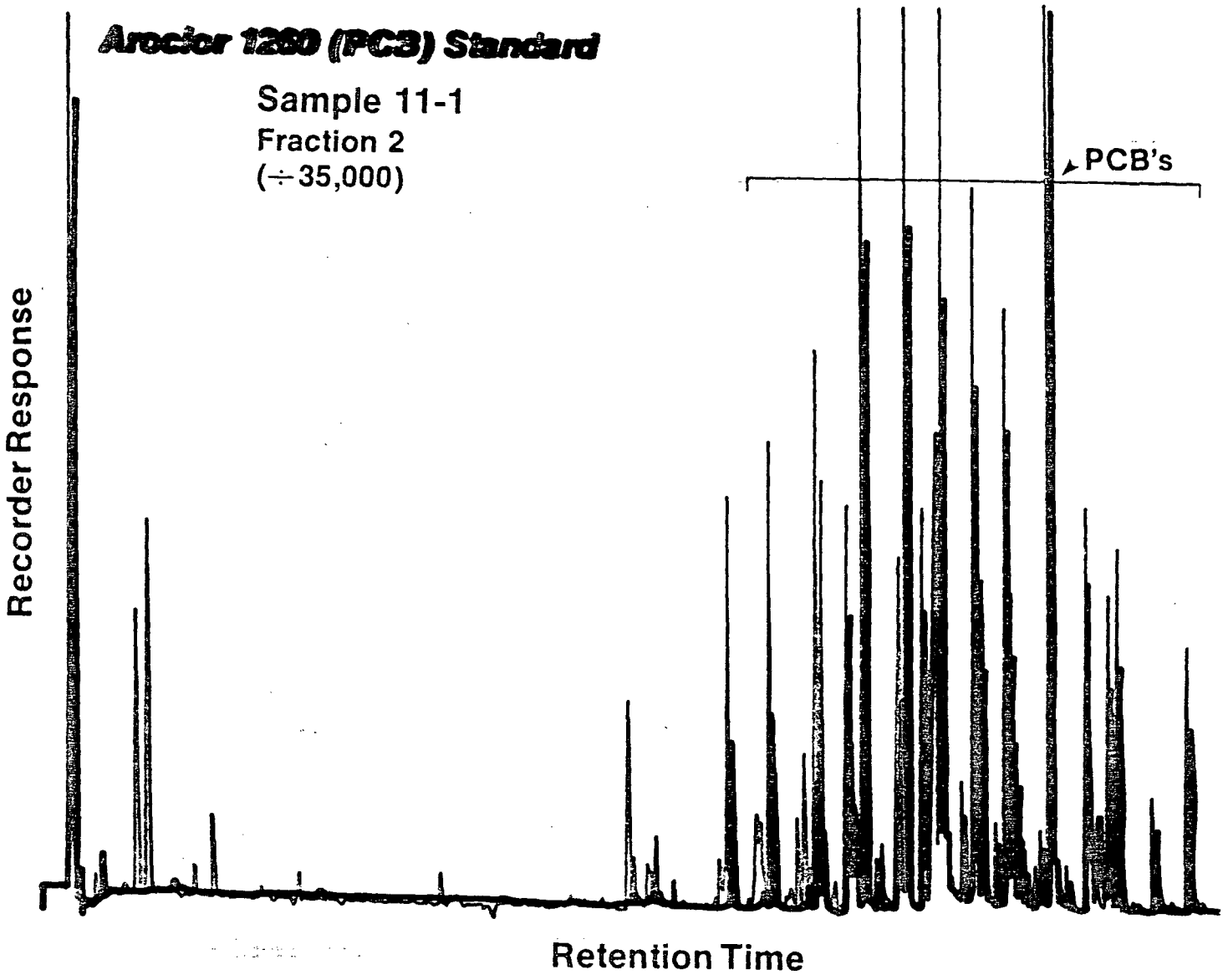

FIG. 9 GC COLUMN PRINT OF SOIL SAMPLES EXTRACT SHOWING PCB PEAKS

FIG. 8 GC COLUMN PRINT OF PCB STANDARD

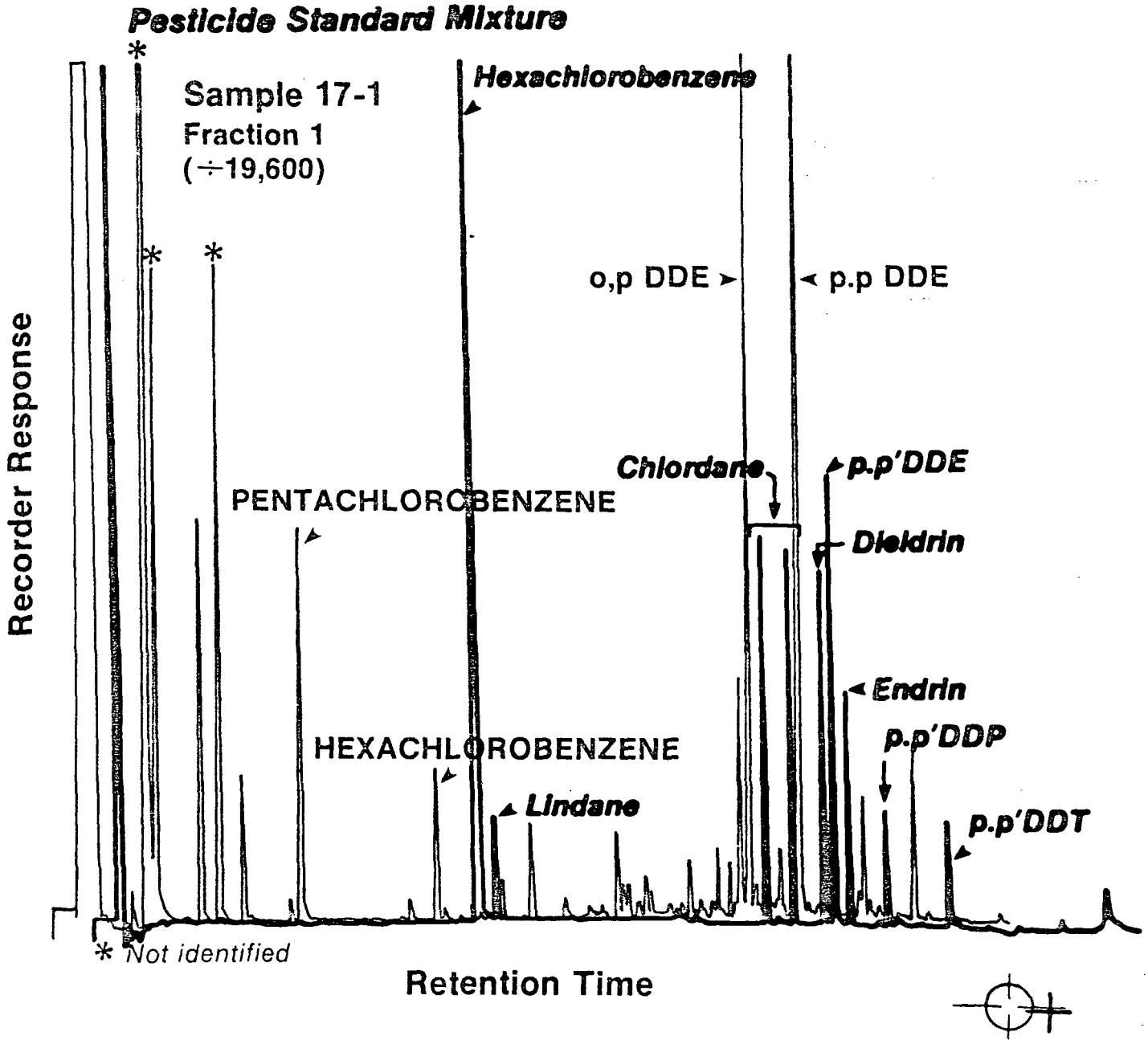

FIG. 10 GC COLUMN PRINT OF STANDARDS FOR SELECT TOXICANTS

FIG 11 GC COLUMN PRINT OF SOIL SAMPLE EXTRACT SHOWING RESPONSES FOR SELECT TOXICANTS

Section 4 - Results of chemical analysis of soil samples

4.1 The concentrations of toxicants in respective soil samples are given in Tables 2, 3, 4, and 5. The first column in the tables identifies the number and location of the soil sample as delineated on the geographical maps of the Olin and check sites (Figures 1 and 2). The second number indicates the depth in the soil profile at which the sample was taken, where (1) indicates a composite sample taken from a core to a depth of 24 inches (30.5 cm) under the asphalt-concrete mantle and number (2) indicates a composite sample from a deep core sampled from 24 to 72 inches (183 cm) in the profile. The concentrations of the toxicants are given in the second column in micrograms per kilogram (ug/kg) or parts per billion (ppb) of air-dry soil. To assess the concentration of the respective toxicants in measures of micrograms per gram (ug/gsoil) or parts per million (ppm) divide the table values by 1000. The symbol (<) indicates values "less than" the stipulated value.

Figure 1 - Map of the Olin site delineating soil sample core location, pre-existing building and structures and site borders.

Figure 2 - Map of check sites delineating geographical reference to Olin site, residential lots (sites of samples) and soil sample core locations in lot site.

Fig. 1

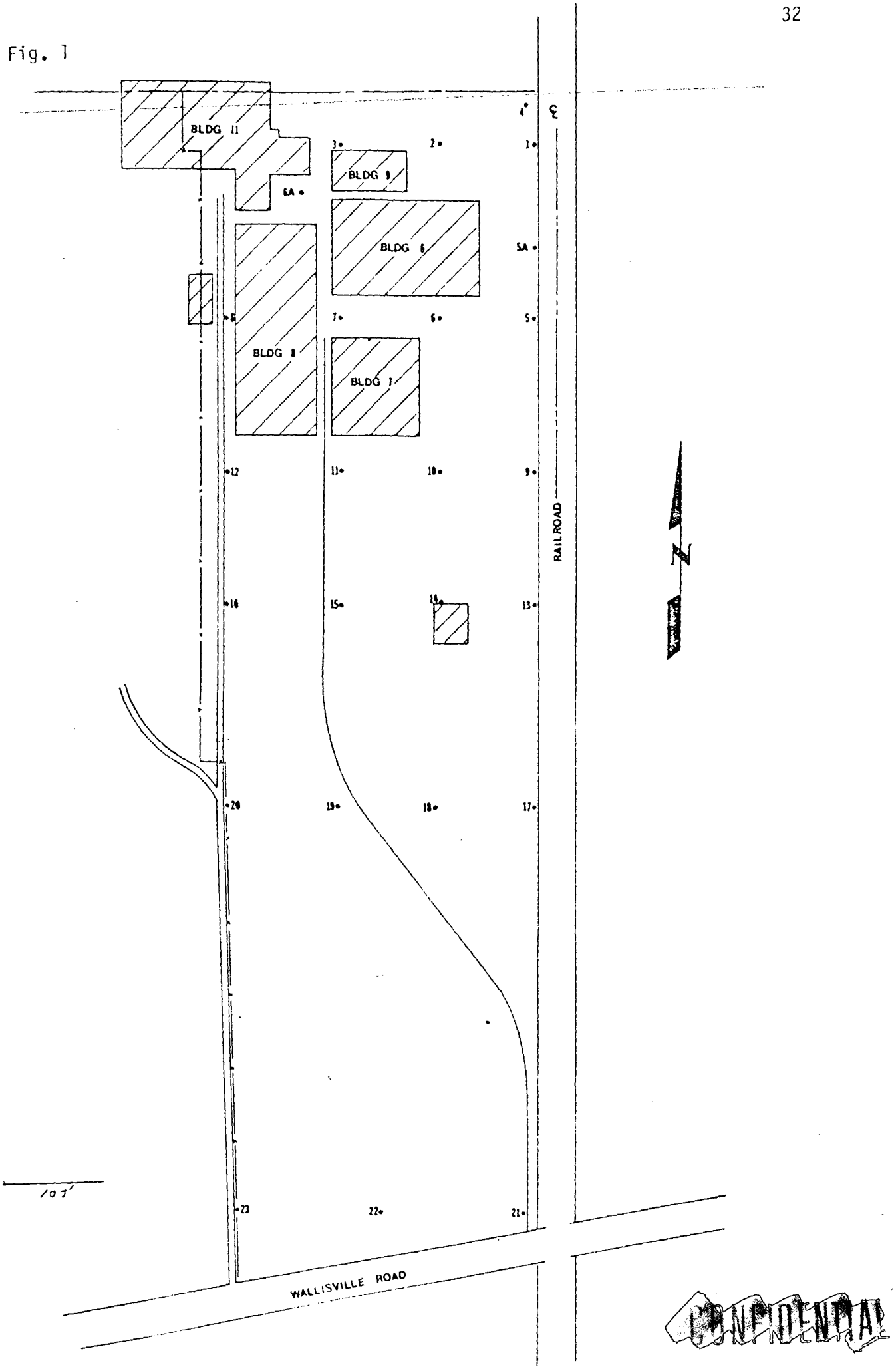

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Fig. 2

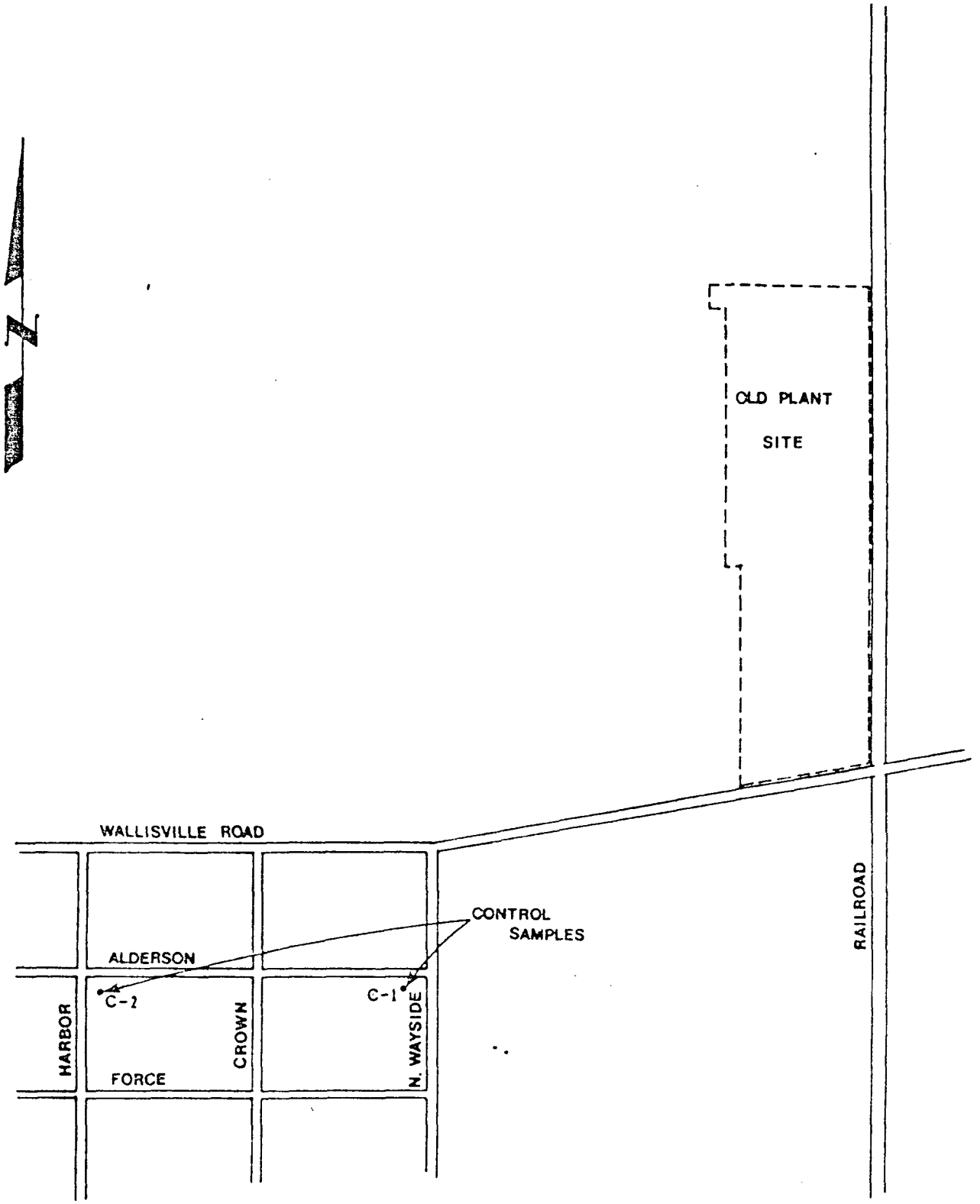


Table 2

Toxaphene concentration (ug/kg) in soil samples from study site.

Sample Designation	Toxaphene Concentration
1-1	1080
2-1	701000
3-1	421000
3-2	342000
4-1	<5
5-1	95
5A-1	<7
6-1	<4
6A-1	71100
7-1	126
8-1	<6
9-1	<5
10-1	7000
11-1	3110
12-1	<4
13-1	27000
14-1	<2
15-1	<5
16-1	<7
17-1	13400
18-1	1560
19-1	<4
20-1	<4
21-1	<4
22-1	40
23-1	7
C1-1	164
C2-1	156

Table 3

Concentrations of DDT and metabolites (ug/kg) in soil samples from study site.

Sample Designation	DDE*	DDD*	DDT*	DDT**
1-1	105	453	248	806
2-1	8000	11100	69800	88900
3-1	17200	36700	22600	76500
3-2	427	17100	15600	33100
4-1	<1	<1	12	12
5-1	<1	<1	35	35
5A-1	1	<1	7	8
6-1	55	40	14	109
6A-1	309	30400	3326	33762
7-1	488	173	39	700
8-1	3	<1	63	66
9-1	19	9	9	37
10-1	1500	3	13600	15100
11-1	1470	1686	616	3769
12-1	<3	<1	9	9
13-1	21300	5930	3470	30700
14-1	783	12200	5100	18100
15-1	<2	<1	10	10
16-1	7	4	34	45
17-1	7104	402	5960	13500
18-1	390	419	1080	1880
19-1	9	24	8	41
20-1	<1	<1	5	5
21-1	4	4	11	19
22-1	79	127	7	206
23-1	12	3	46	61
C1-1	2	<1	688	690
C2-1	126	<1	24	150

* includes both o,p and p,p' isomers

** DDT = DDE + DDD + DDT

Table 4

Concentrations of selected chlorinated hydrocarbon insecticides (ug/kg) in soil samples from study site.

Sample Designation	Hexachlorocyclohexane	Chlordane	Dieldrin
1-1	3230	122	18
2-1	11100	10800	4260
3-1	5600	10700	2190
3-2	4180	3041	2471
4-1	166	1	<1
5-1	6	<1	<1
5A-1	55	1	<1
6-1	<1	3	<1
6A-1	2440	10690	814
7-1	12	65	<1
8-1	82	<1	<1
9-1	32	1	<1
10-1	147	485	310
11-1	120	765	36
12-1	<2	<1	<1
13-1	641	2430	1080
14-1	<2	474	185
15-1	5	<1	<1
16-1	7520	<1	<1
17-1	361	633	490
18-1	5	215	22
19-1	<2	6	2
20-1	<2	<1	<1
21-1	<2	1	<1
22-1	<2	56	31
23-1	<2	18	10
C1-1	2	10	20
C2-1	<2	<1	<1

Table 5

Concentration of chlorinated benzenes and chlorinated biphenyls (PCB) (ug/kg) in soil samples from study site.

Sample Designation	Pentachlorobenzene	Hexachlorobenzene	PCB*
1-1	8	63	1
2-1	2560	70500	10700
3-1	2930	12400	41300
3-2	--	1680	2080
4-1	<1	<1	27
5-1	<1	<1	<1
5A-1	<1	7	<2
6-1	<1	<1	<2
6A-1	8	81	175
7-1	<1	34	8490
8-1	<1	<1	<1
9-1	<1	<1	<1
10-1	20	86	51
11-1	20	43	16800
12-1	<1	<2	4
13-1	183	212	176
14-1	53	153	2870
15-1	<1	<1	<1
16-1	5	<1	273
17-1	64	79	393
18-1	4	13	174
19-1	<1	1	<1
20-1	<1	<1	5
21-1	<1	<1	<1
22-1	3	<3	1170
23-1	<1	5	20
C1-1	<1	4	7
C2-1	<1	<2	2580

*Calculated as the sum of Aroclor 1254 and Aroclor 1260.

4.2 Symap projection maps of concentration - areal distribution of soil toxicants in Olin and check sites; Figures 12, 13, 14, 15, 16, 17, 18, 19, and 20.

Symap as used in this survey is a computer program which provides a graphic assessment of the concentration - areal distribution of specific toxicants over a designated geographical area[1], in this case the Olin and check sites from discrete soil sample concentration and location. The concentration range of the respective toxicants is divided into discrete values which are uniformily distributed between soil sample locations by isoline or contour lines. However, in this study the concentration values are represented by raster symbols where concentration are differentiated by grey-tone shading or hues within small grids distributed over the area, an effect comparable to contour lines. This treatment of discrete data points (the soil sample concentration and location) does not "smear" or average the data over the area between sample location as for example a location having very high toxicant levels (toxic waste disposal site) adjacent to several low-level sites, but rather provides the best estimates of toxicant concentrations in discrete values along the range of toxicant concentration between the sample site of high concentration and the concentration of the adjacent samples.

The Symap was prepared using 2,166 raster grids as shown by the measurement marks along the X and Y axis encompassing the actual limits of the Olin site (Figures 12-20). The concentration range for each toxicant is divided into 9 discrete values represented by raster hues labeled with value numbers.

To quantitatively estimate the areal distribution of a respective value number for a specific toxicant, simply divide the number of occurrances by 2,166 to determine the proportion of the Olin site contaminated.

The check sites were alloted a total of 325 occurrances or 162 per site. To concerve space the Symaps of the check sites were placed within the extra space provided for the Olin site in each Symap projection. The check sites are represented by the 2 square areas in the lower left hand corner of each Symap.

The concentration differential between value numbers (codes) 8 and 9 for the toxicants in Table 6 is 10 fold because the extreme range of toxaphene was taken as a standard. However, for the calculations used to generate the data for the assessment of DDT, PCB. pentachlorobenzene and hexachlorobenzene a range of 50,000 - 100,000 ppb and a mid point concentration of 75,000 ppb or 75 ppm was used in code 9.

To transfer a point or an area from either the Symap projection and the area map, locate the area or point of interest by the intersecting grid marks on the X and Y axis and transfer the counts to the other map.

1) James W. Cerny, 1972. Use of the Symap Computor Mapping Program. J. of Geography 71, No. 3, March pp. 167.

TABLE 6 - CODE OF TOXICANT CONCENTRATIONS FOR TOXAPHENE, DDT*, PCB*, PENTACHLOROBENZENE*, AND HEXOCHLOROBENZENE*.

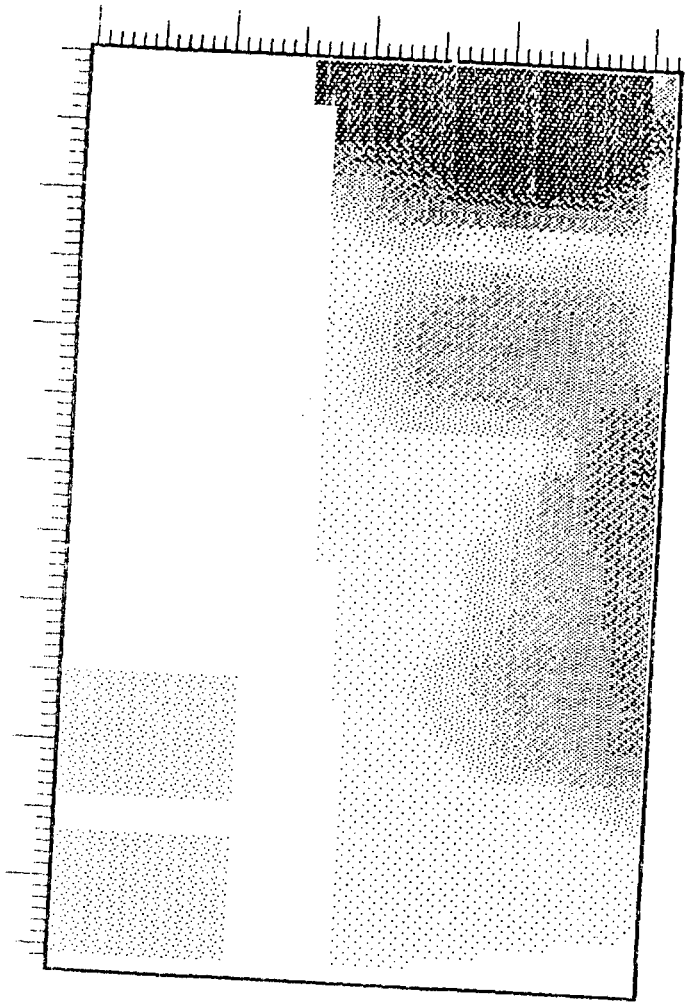
VALUE NUMBER	CONCENTRATION RANGE	MIDPOINT CONCENTRATION	
	-PPB-	PPB	PPM
1	0 - 100	50	0.05
2	101 - 200	150	0.15
3	201 - 1000	600	0.60
4	1001 - 2000	1500	1.50
5	2001 - 5000	3500	3.50
6	5001 - 10,000	7500	7.50
7	10,000 - 25,000	17,500	17.50
8	25,001 - 50,000	37,500	37.50
9	50,001 -700,000*	375,000	375.00

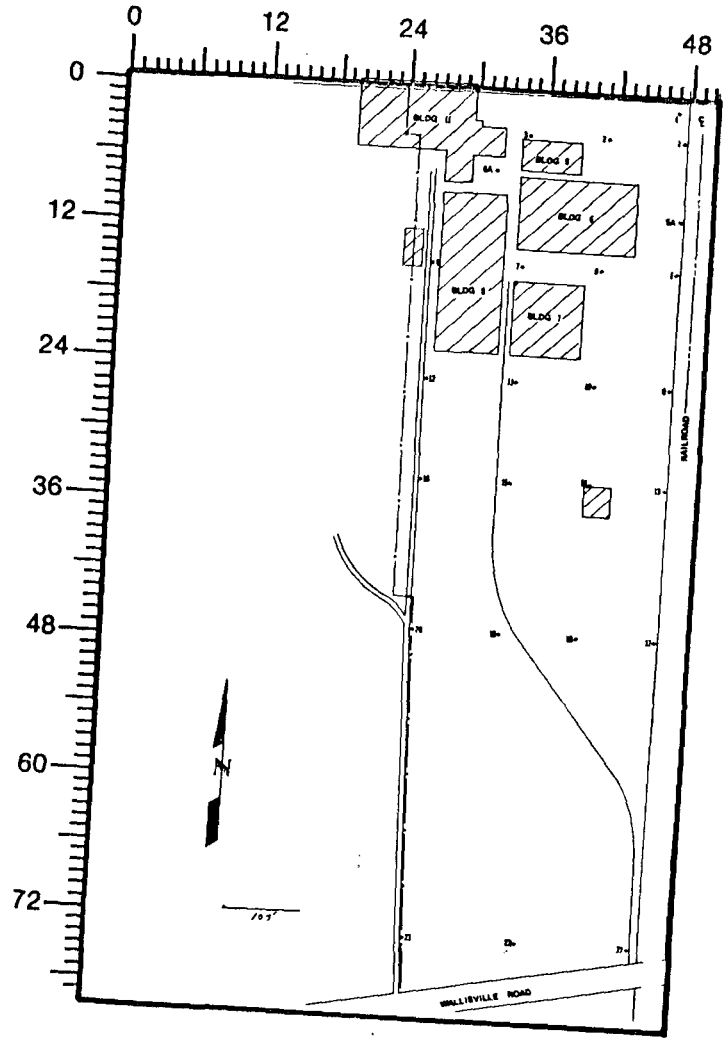
*THESE PECTICIDES HAVE A MIDPOINT CONCENTRATION OF 75,000 PPB OR 75. PPM FOR VALUE RANGE IN VALUE NUMBER 9.

TABLE 7 - CODE OF TOXICANT CONCENTRATIONS FOR CHLORDANE, DIELDRIN, AND HEXACHLOROCYCLOHEXANE IN UPPER SOIL SAMPLES OF OLIN AND CHECK SITES FOR INTERPRETATION OF SYMAPS.

VALUE No.	CONCENTRATION RANGE	MIDPOINT CONCENTRATION	
	-PPB-	PPB	PPM
1	0 - 10	5	0.005
2	11 - 20	15	0.015
3	21 - 100	60	0.060
4	101 - 200	150	0.150
5	201 - 500	350	0.350
6	501 - 1000	750	0.750
7	1001 - 2500	1750	1.750
8	2501 - 5000	3750	3.750
9	5001 - 7000	6000	6.000

FIGURES 12 TO 20 ARE SYMAP PROJECTION MAPS OF THE SPECIFIC TOXICANTS OVER THE OLIN AND CHECK SITES.





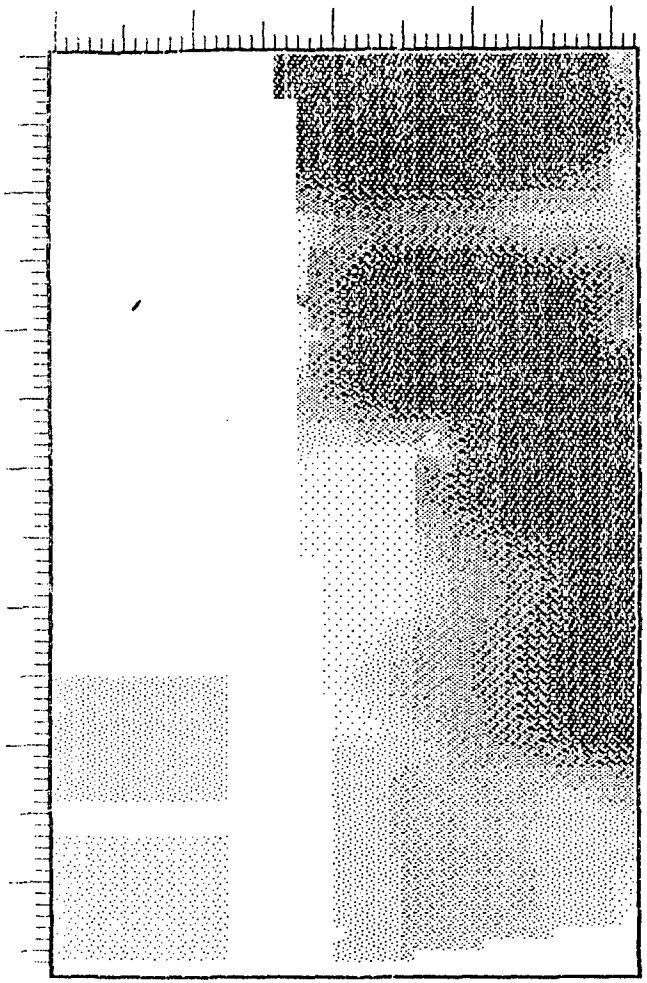
TITLE: TOXAPHENE. CONCENTRATION. MAP

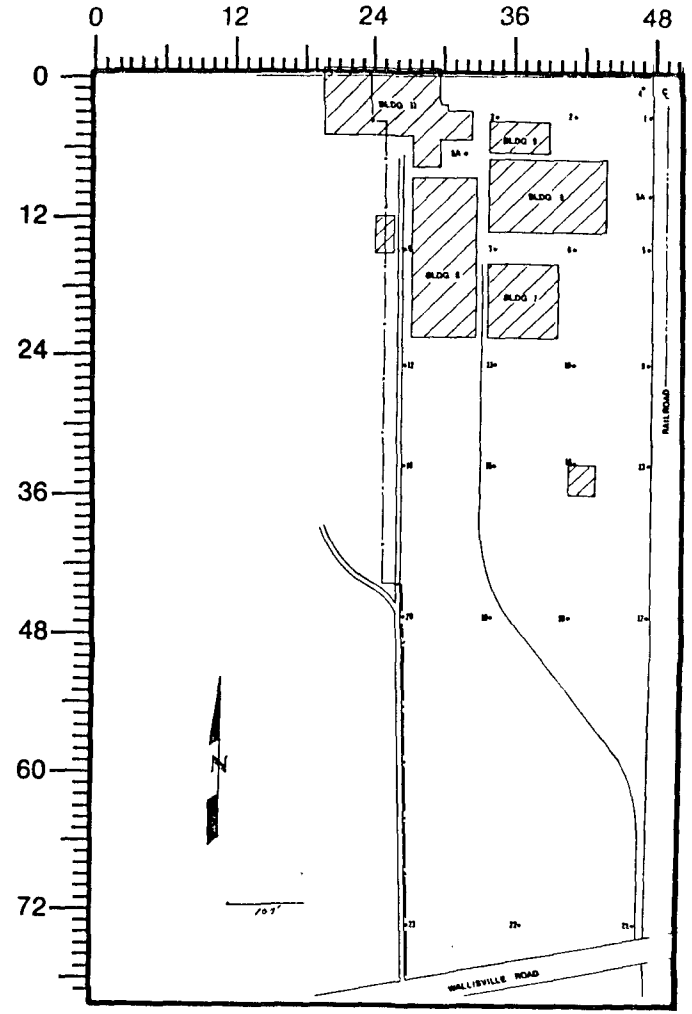
MAP: TOXAPHENE

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURRANCES	813	415	251	134	234	185	147	54	263	0

Fig. 12- SYMAP for Toxaphene





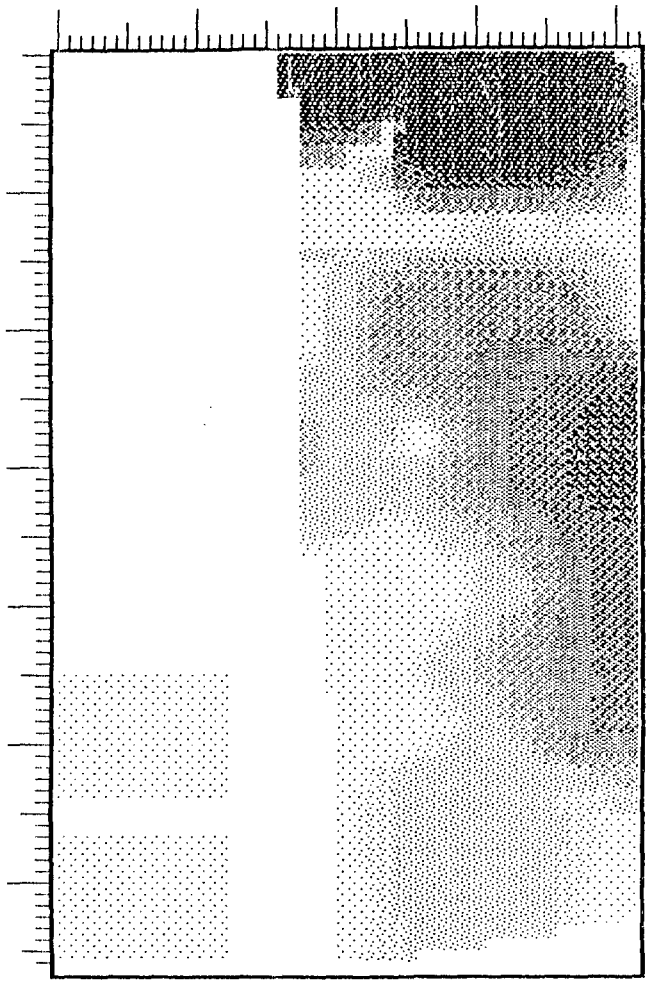
TITLE: DDT.CONCENTRATION.MAP

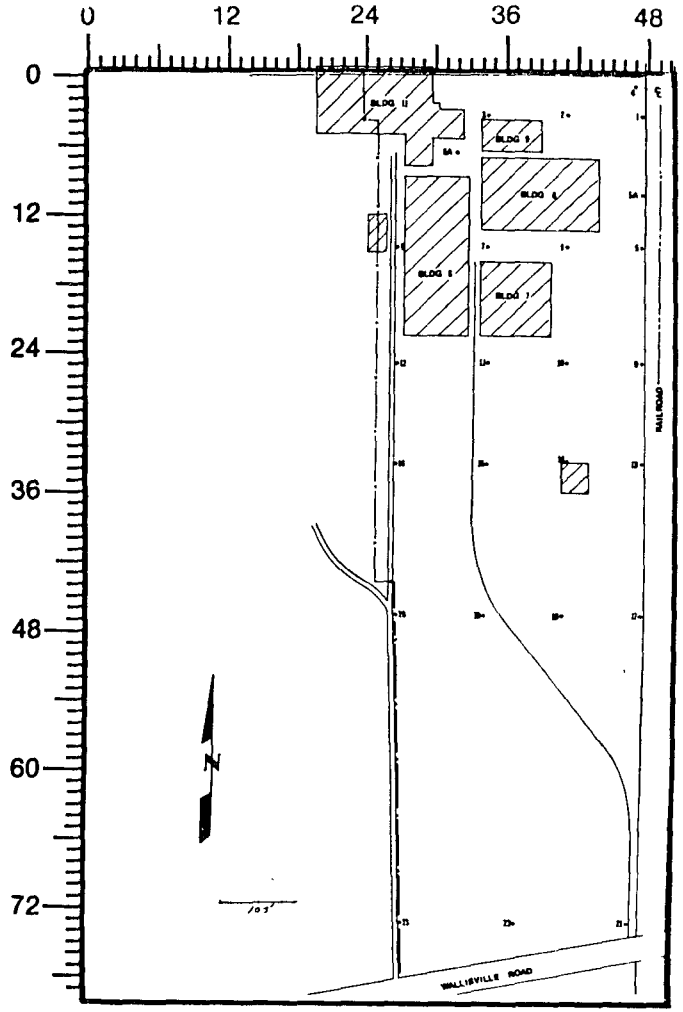
MAP: DDT

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	187	192	439	251	97	124	192	161	852	0

Fig. 13- SYMAP for DDT





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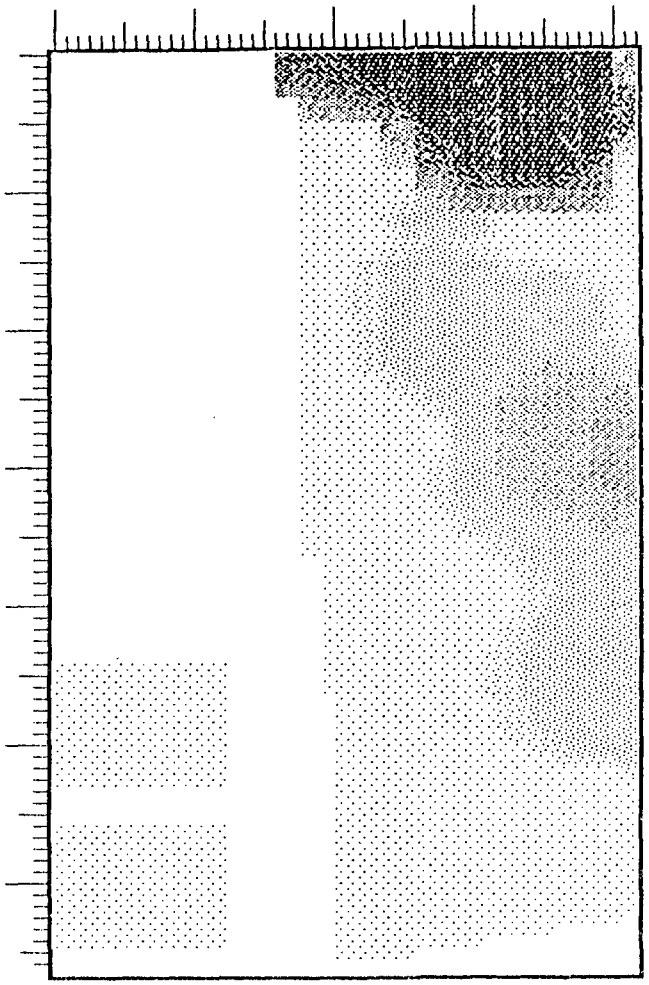
TITLE: PENTACHLOROBENZENE. CONCENTRATION. MAP

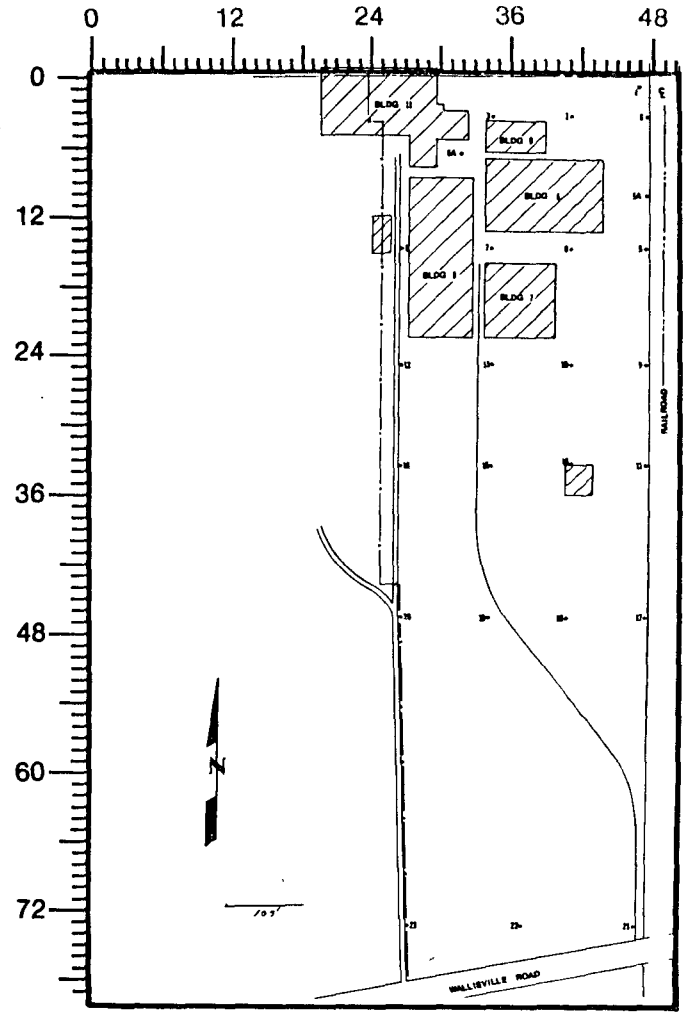
MAP: PENTACHLOROBENZENE

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	737	152	536	138	265	155	175	86	252	0

Fig. 14- SYMAP for Pentachlorobenzene





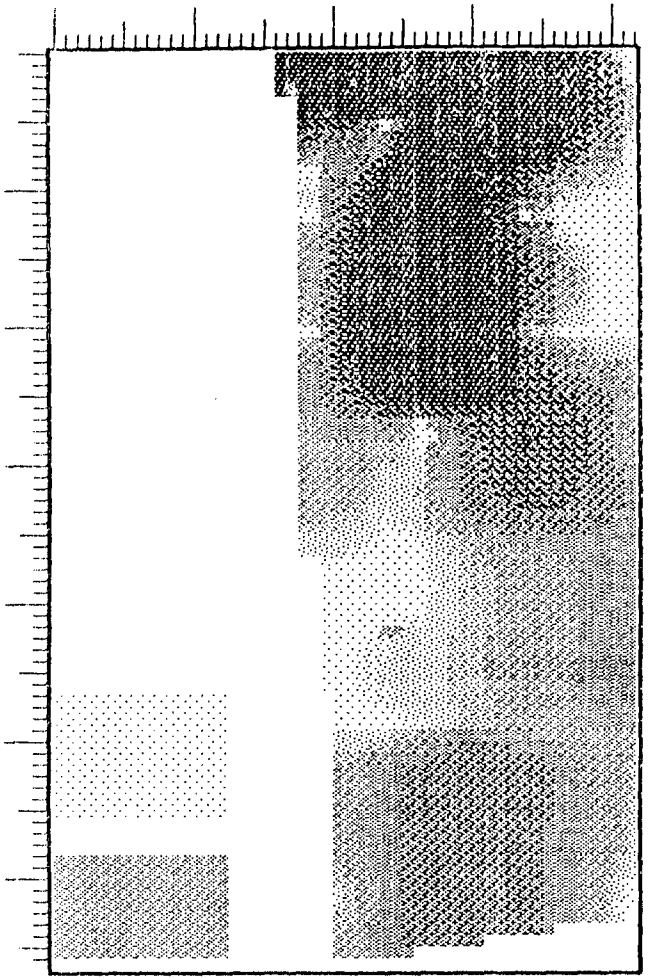
TITLE: HEXACHLOROBENZENE. CONCENTRATION. MAP

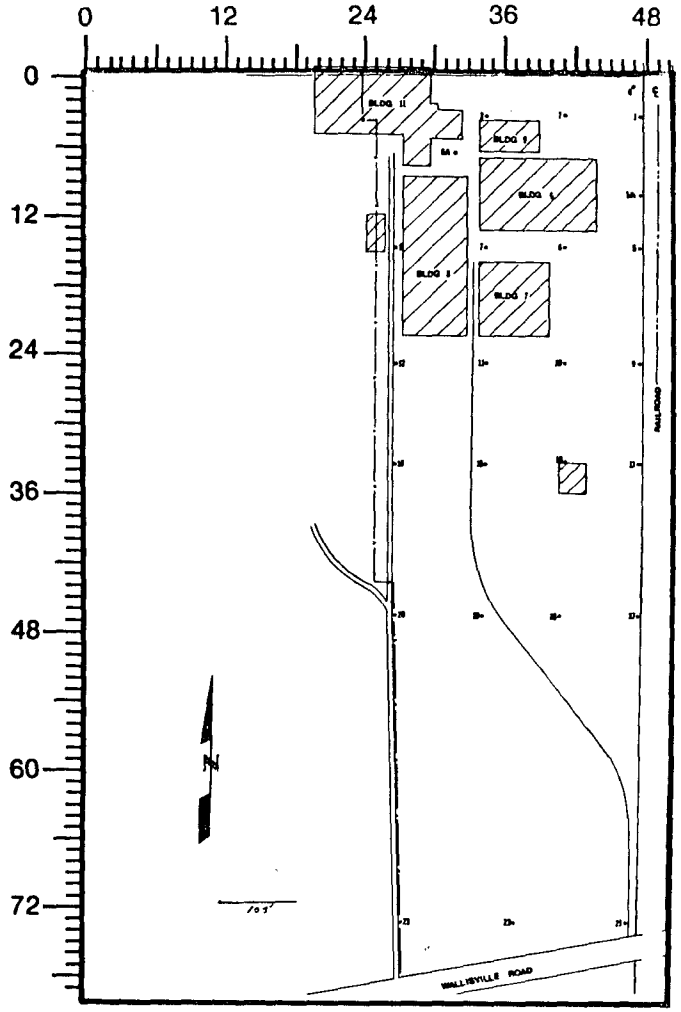
MAP: HEXACHLOROBENZENE

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	1423	131	177	130	50	22	32	15	186	0

Fig. 15- SYMAP for Hexachlorobenzene





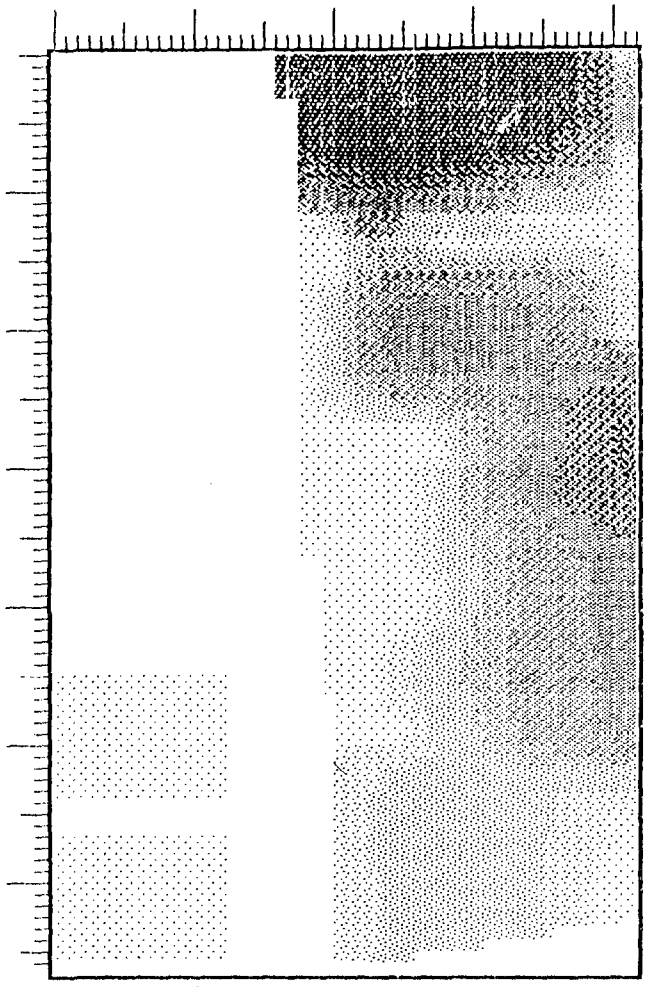
TITLE: PCB.CONCENTRATION.MAP

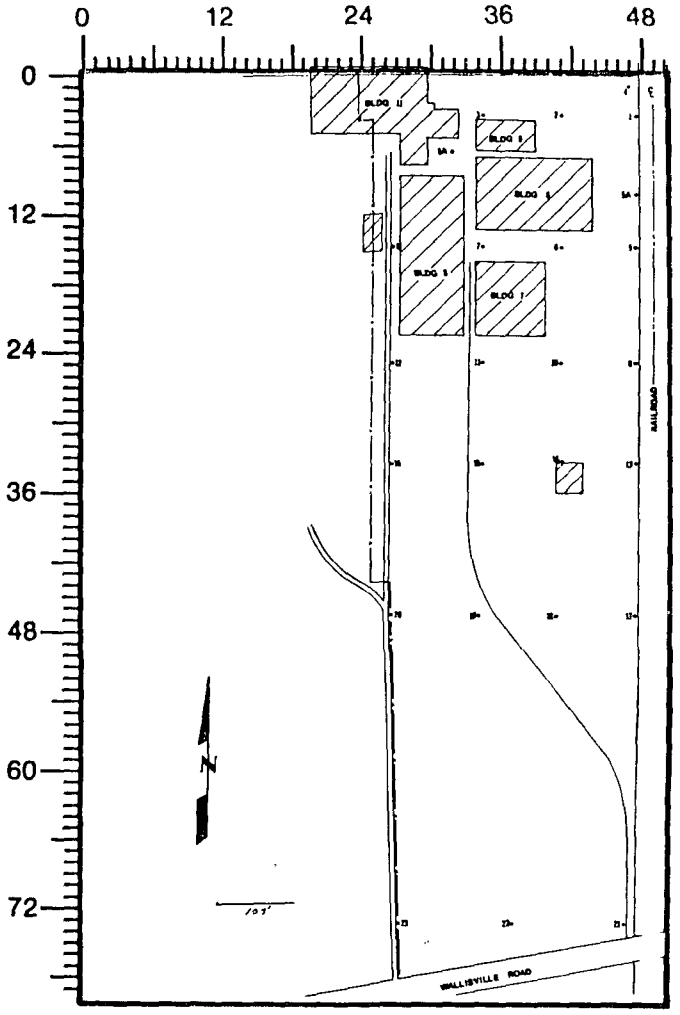
MAP: PCB

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	344	37	140	116	480	312	366	172	499	46

Fig. 16- SYMAP for PCB





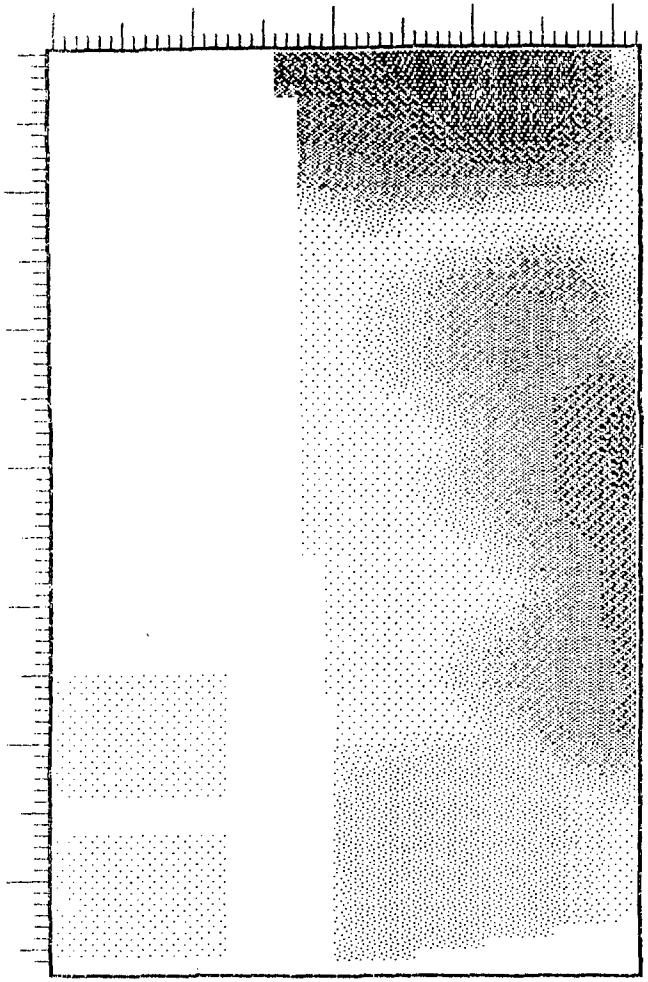
TITLE: CHLORDANE.CONCENTRATION.MAP

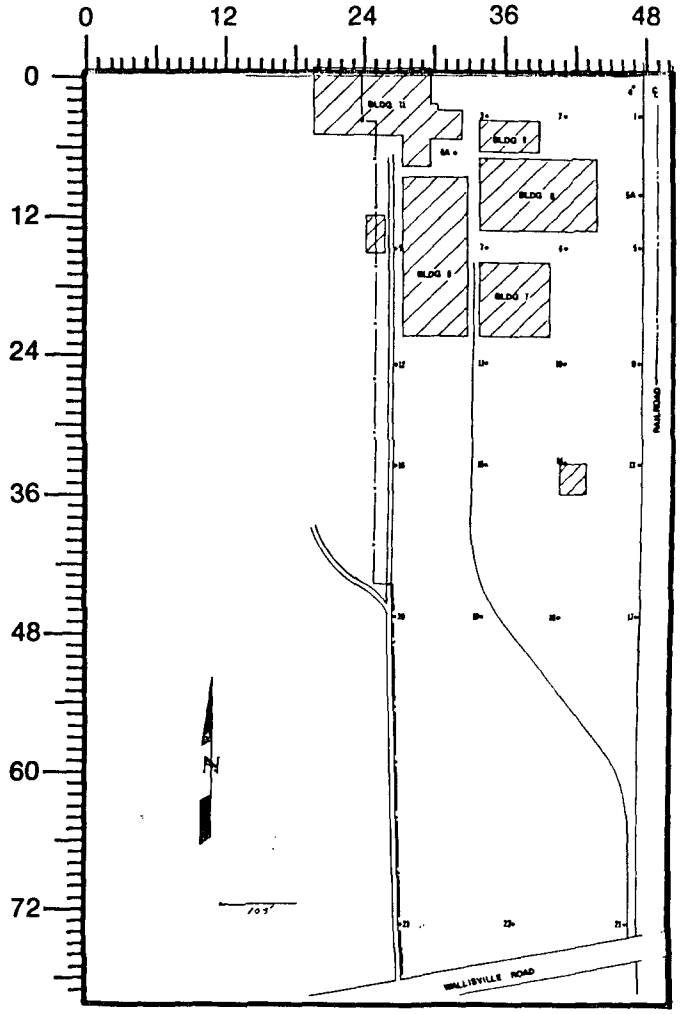
MAP: CHLORDANE

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	668	246	454	166	310	248	113	57	231	

Fig. 17- SYMAP for Chlordane





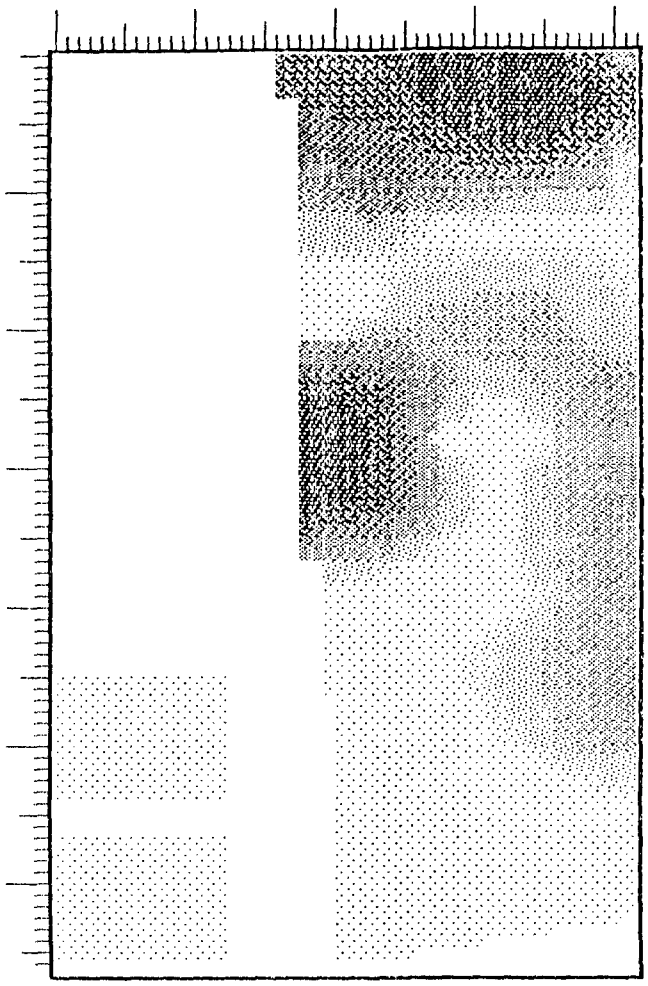
TITLE: DIELDRIN.CONCENTRATION.MAP

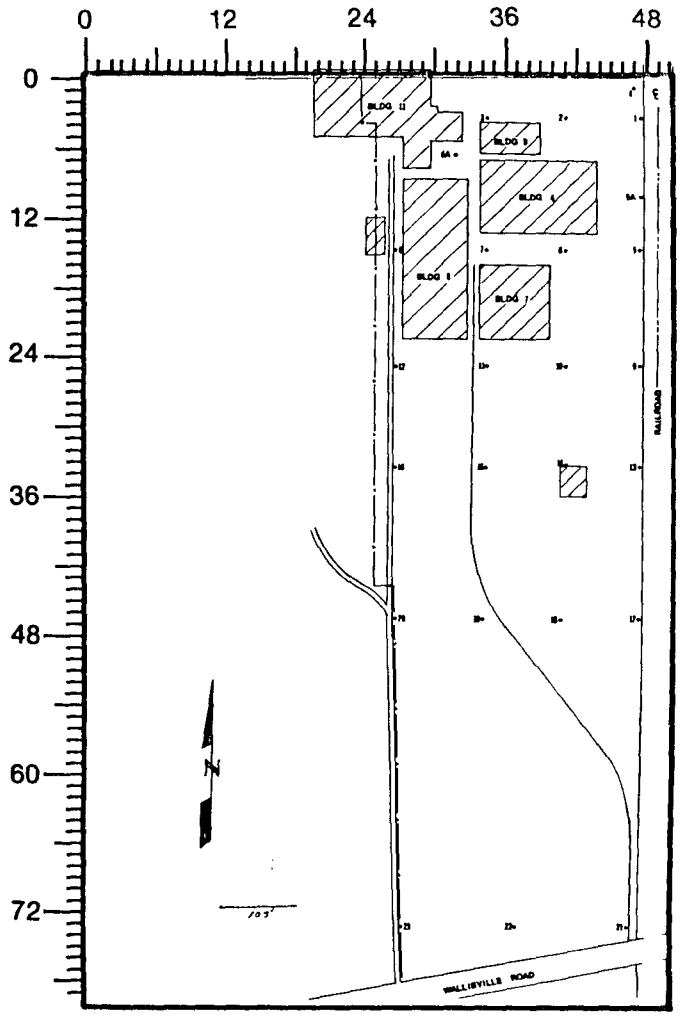
MAP: DIELDRIN

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	854	175	521	12	198	216	195	112	104	

Fig. 18- SYMAP for Dieldrin





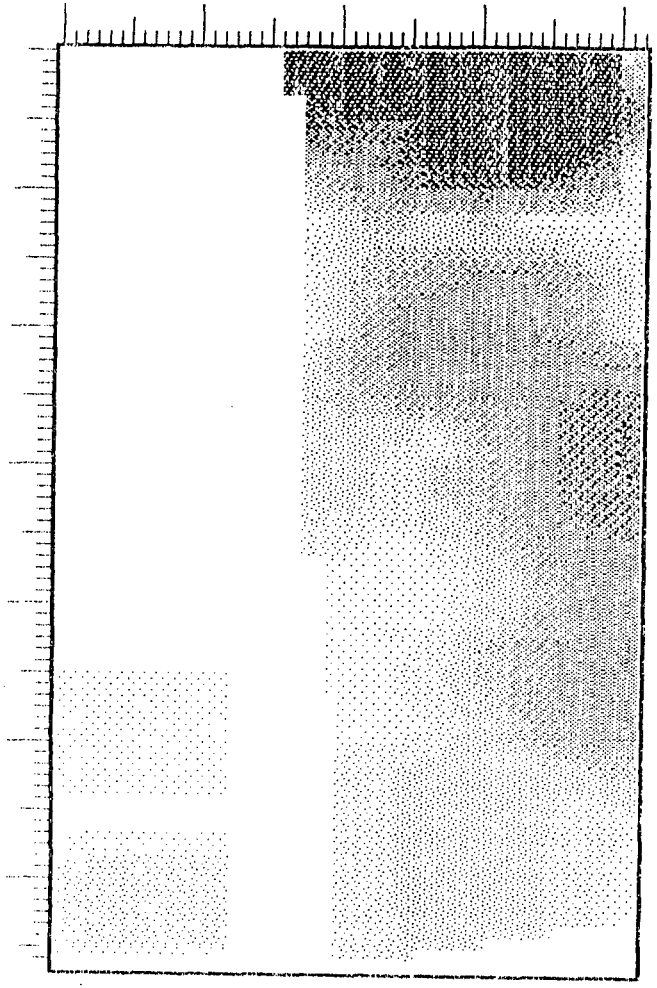
TITLE: HEXACHLOROCYCLOHEXANE.CONCENTRATION.MAP

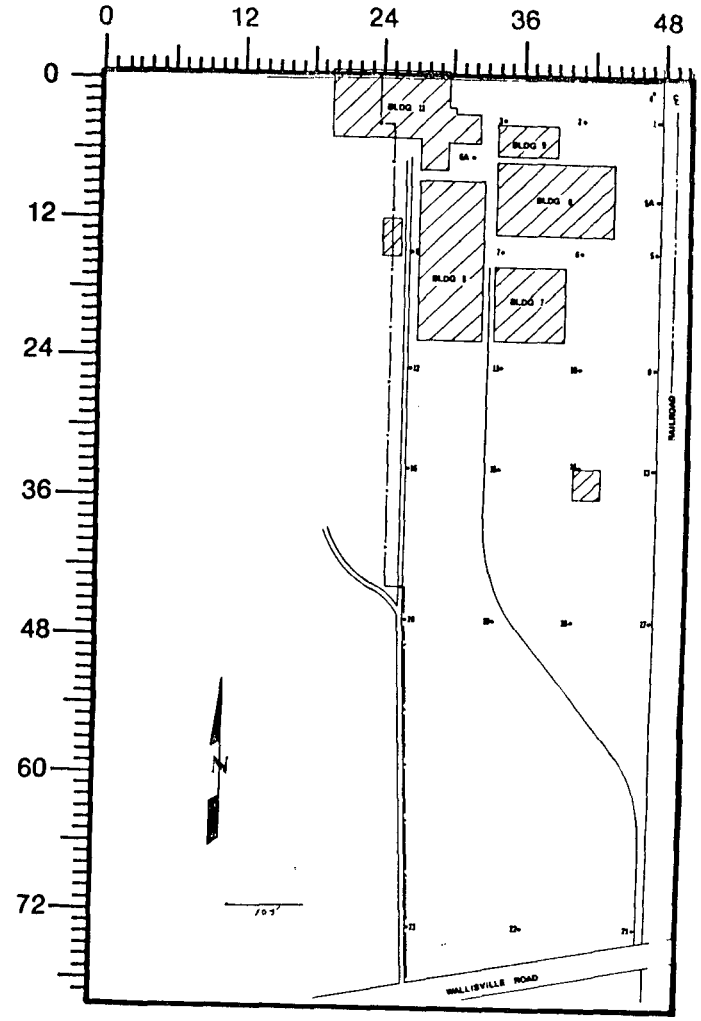
MAP: HEXACHLOROCYCLOHEXAN

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	1153	129	270	208	203	93	113	164	163	0

Fig. 19- SYMAP for Hexachlorocyclohexane





TITLE: TOTAL.TOXICITY.CONCENTRATION.MAP

MAP: TOTAL.TOXICITY

COUNTS BY SYMBOL TYPE

VALUE	1	2	3	4	5	6	7	8	9	0
OCCURANCES	403	453	479	184	229	356	114	39	283	

Fig 20- SYMAP for total toxicants

4.3 Estimated amounts and concentrations of toxicants absorbed in soil profile of Olin and check sites and proportion of the respective sites contaminated by specific toxicants. Estimates were based on Symap concentrations and occurrance. Tables 8, 9, 10, and 11.

TABLE 8 - ESTIMATED AMOUNTS OF TOXICANT RETAINED IN THE UPPER SOIL CORES OVER THE OLIN SITE.(1)

TOXICANT	QUANTITY			
	(2)	POUNDS	(2)	KILOGRAMS
*TOXAPHENE	(0.70)	2271	(0.32)	1033
*DDT	(3.02)	982	(1.37)	466
**PENTACHLOROBENZENE	(0.22)	356	(0.10)	162
**HEXACHLOROBENZENE	(0.22)	227	(0.10)	103
**PCB	(8.12)	726	(3.69)	330
*CHLORDANE	(0.22)	40	(0.10)	18
*DIELDRIN	(0.22)	23	(0.10)	10
**HEXACHLOROCYCLO-HEXANE	(0.22)	26	(0.10)	12
TOTAL OVER OLIN SITE		4641		2114
CHECK SITE-TOTAL	(12.9)		(5.85)	

(1)EPA ESTABLISHED THAT THE DISCHARGE INTO THE ENVIRONMENT OF 1 POUND (0.454 KILOGRAM) OF THE FOLLOWING TOXICANTS* AND 10 POUNDS (4.54 KILOGRAM)** CONSTITUTE A HAZARDOUS WASTE DISCHARGE (SEE REFERENCE No. 40 CFR 117.11.

(2) POUNDS OF RESPECTIVE TOXICANTS IN CHECK SITE.

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TABLE 9 - ESTIMATE MEAN CONCENTRATIONS OF TOXICANTS IN UPPER SOIL CORES IN OLIN SITE AND CHECK SITE.(1)

TOXICANT	SITE CHECK	SITE OLIN	CONC. RATIOS OLIN/CHECK
	-- PPM --		
TOXAPHENE	0.15	48.7	324
DDT	0.37	34.6	94
PENTACHNOROBENZENE	0.05	12.9	258
HEXACHLOROBENZENE	0.05	7.91	158
PCB	1.75	24.8	15
CHLORDANE	0.005	0.99	198
DIELDRIN	0.005	0.77	154
HEXACHLOROCYCLOHEXANE	0.005	0.92	184
		$\bar{x}$	173

(1) CONCENTRATIONS FOR RESPECTIVE TOXICANTS ARE MEAN VALUES BASED ON OCCURRANCES AND CONCENTRATION VALUES DELINEATED BY SYMAP FOR RESPECTIVE TOXICANTS.

TABLE 10 - ESTIMATED PERCENTAGE OF OLIN SITE CONTAMINATED WITH SPECIFIC TOXICANTS EXCEEDING 1 PPM CONCENTRATION IN SOIL (1) AND OLIN/EPA STANDARD CONCENTRATION COMPARED.

TOXICANT	EXCEEDS 1 PPM - % OF SITE -	MEAN CONC. RATIO OLIN/E
TOXAPHENE	46.9	48.7
DDT	77.4	34.6
PENTACHLOROBENZENE	49.5	12.9
HEXACHLOROBENZENE	21.5	7.9
PCB	82.3	24.8
CHLORDANE	18.6	0.99
DIELDRIN	19.0	0.77
HEXACHLOROCYCLOHEXANE	20.3	0.92
CHECK SITE TOTAL	00.0	

(1)THE 1 PPM CONCENTRATION IS USED BY EPA AS A GENERIC LEVEL FOR ALL ORGANIC PESTICIDES IN SOIL WHICH IF EXCEEDED, IS TERMED A HAZARDOUS CONCENTRATION.

REFERENCE: PERSONAL COMMUNICATION NOVEMBER, 1982
MR. DENNIS GUILD
EPA DALLAS, TEXAS 1201 ELM ST.
REGION VI
ENFORCEMENT DIVISION

TABLE 11 - RELATIVE ESTIMATED MEAN CONCENTRATIONS OF TOXICANTS IN OLIN AND CHECK SITES TO ASSESS MAGNITUDE OF SOIL ADULTERATION.

TOXICANT	CHECK(1) SITE	% OF OLIN SITE EXCEEDING CHECK VALUES	MEAN OF CONC. TOXICANT IN OLIN SITE EXCEEDING CHECK VALUES
	PPM	%	PPM
TOXAPHENE	0.15	59	48.7
DDT	0.37	90	34.6
PENTACHLOROBENZENE	0.05	81	12.9
HEXACHLOROBENZENE	0.15	50	7.9
PCB	1.75	77	24.8
CHLORDANE	0.005	84	0.99
DIELDRIN	0.005	76	0.77
HEXACHLOROCYCLO-HEXANE	0.005	62	0.92
		$\bar{x}$ 72.3	

(1) REPRESENTS 100% OF THE CHECK SITE.

4.4 Estimated concentrations of toxicants in ambient soil solutions in Olin and check site: Tables 12, 13, 14, 15, 16, 17, 18, and 19.

The estimated concentrations of soil toxicants in the ambient soil solution based on octanol-water partition coefficients (K_{ow}) for the respective pesticide toxicants in soil samples are given in Tables 12-19. The impact of organic toxicants retained in the soil matrix on the quality of water bathing the matrix can be assessed by measuring the concentration of toxicants in the soil solution in equilbrium with soil particularly the organic carbon component.(3) However, to determine the equilbrium constant for a specific pesticide, in soil, absorption isotherms of soils with different contents of organic matter and/or organic carbon must be developed. Intensive investigations have established however that octanol-water partition coefficients (K_{ow}) for specific pesticides (that is, the equilbrium constant (Ratio) of the pesticide concentration in a non-polar solvent like octanol and a polar solvent, water) are correlated with equilbrium constants of pesticides in water and soil organic carbon (K_{oc}) in a highly significant linear relationship (1,2) expressed by the following regression equation:

$$\text{Log } K_{oc} = 1.019 \times K_{ow} - 0.18 \quad \text{equation 1}$$

Thus, using equation 1, it becomes possible to determine the K_{oc} for any pesticide with a known K_{ow}. Once K_{oc} is determined then the following relationship permits the calculation of the toxicant in the ambient solution:

$$K_{oc} = \frac{\text{ug toxicant absorbed/g of organic C in soil}}{\text{ug/ml toxicant in ambient sol.}} \quad \text{equation 2}$$

Since the K_{oc}, organic carbon concentration of Lake Charles Clay, and concentration of toxicant absorbed by the soil are known, the calculation for the concentration of toxicant in ambient solution is straight forward. Chiou[2] has noted that absorbient - water partition coefficients as compared to octanol-water systems give linear isotherm ranging up to 2000 ppm of organic toxic in equilbrium concentrations. Thus, this method of estimating solution concentration for specific toxicants has been used to assess bio-accumulation of pesticides.[4]

A recent reevaluation of the use of octanol-water partition coefficients to estimate the retention of pesticides in soil has shown that the high exchange capacity of expanding clays specific in soils contributes substantially to the retention of organic pesticides as well as the organic carbon [5](also see Chiou [2]. The equilbrium solution concentrations of the toxicants in the Olin site could increase due to the presence of highly reactive clays coated with organic matter inherent in the soils of the Lake Charles series. However, to assess this suggestion, soil isotherms would be required for specific pesticides under conditions where the various components of the Lake Charles soil are treated as independent variables.

Presence of toxic organic pesticides in the deeper soil profile can be attributed to the movement of finer soil particale-size fractions (usually high in organic carbon and specific surface area) which have a larger sorption partition coefficient than coarser fractions and thus sorb more toxicant.[6]

In addition, the relatively high equilbrium concentrations of toxicants in soil solutions within the soil surface layer are reduced when the solutions percolate into deeper layers and toxicants are sorbed by

the soil matrix. Thus, the equilbrium concentrations of toxicants in soil solution reaching the water table (in the Olin site; a depth of 20') are usually attenuated. However, the very high levels of soil toxicants in select soil sample locations in the Olin site precludes a marked reduction of toxicant concentrations at the water table, a reduction estimated at 40% of surface equilbrium levels. No water samples (E. ditch, wells or cores) were taken at the Olin site because the toxicant concentration in water would vary with rainfall, runoff, and contribution from unknown sites thus confounding any definitive effect of the soil from the Olin site may have had. In addition, soil temperature and pH effect toxicant concentrations in water, but only very slightly. Measurement of these parameters would not significantly effect the result developed by the partition calculations.

Literature Cited

(1) Chiou, C.T., Louis Peters, V. Freed 1979. A physical concept of soil-water equilbrium for nonionic organic compounds, Science Nov. 16, vol. 206, pp. 831-832.

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(3) Rao, P.S.C. and Davidson, J.M. 1980. Estimation of pesticide retention and transformation parameters required in non-point source pollution models. In Environmental Impact of Non-Point Source Pollution, Ed. Overcash M.R., Davidson J.M. Pub. Ann Arbor Sci. Publ. Inc.

(4) Chiou, C.T., V.H. Freed, D.W. Schemedding, R.L. Kohnort 1977. Partition coefficients and bio-accumulation of selected organic chemicals. Environ Sci, Technol. 11: 475-478.

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(6) Rao, P.S.C., Nkedi-Kizza, P. and Davidson, J. M. 1981. In Preceedings at the National Conference on Agricultural Management and Water Quality; Iowa State University, Ames, Iowa, Mag, 1981.

4.4 Estimated concentrations of toxicants in ambient soil solution of Olin site based on Symap concentration - areal distribution projections. Tables 12-19.

TABLE 12 - EQUILBRIUM CONCENTRATIONS OF TOXAPHENE ESTIMATED IN AMBIENT SOIL SOLUTION OF UPPER SOIL CORES IN OLIN AND CHECK SITE CALCULATED FROM CONCENTRATION VALUES OF SOIL SAMPLES EXCEEDING 1 PPM AND TOXAPHENE EXPERIMENTALLY DERIVED K VALUES.(1)

TOXAPHENE(2) IN SOIL CORES	EQUILBRIUM(3) CONC. OF TOXAPHENE IN SOIL SOLUTION		OCCURRENCE IN SITE
UG/G	UG/ML		%
1.5	0.08		6.2
3.5	0.19		10.8
7.5	0.42		8.5
17.5	1.02		6.8
37.5	2.18		2.5
375.0	21.91		12.1
	$\bar{X}$ 6.04	TOTAL OF SITE	46.9
CHECK SITE			
>1.0	0.0		100

(1) K VALUES GIVEN IN: P.S.C. RAO AND J.M. DAVIDSON, 1980. ESTIMATION OF PESTICIDE RETENTION AND TRANSFORMATION PARAMETERS REQUIRED IN NON-POINT SOURCE POLLUTION MODELS. ENVIR. IMPACT OF NON-POINT SOURCE POLLUTION EDIT. M.R. OVERCASH AND J.M.DAVIDSON, ANN ARBOR SCIENCE PUBL. INC.

(2) MIDPOINT VALUES OF CONCENTRATION RANGES USED IN SYMAP.

(3) MAXIMUM ALLOWABLE CONCENTRATION IN COMMUNITY AND NAVIGABLE WATERS ESTABLISHED BY EPA IS 0.005 MG/L (UG/ML, PPM). REFERENCE: 40 CFR 141.12 AND 40 CFR 129.103 (3).

TABLE 13 - ESTIMATED EQUILBRIUM CONCENTRATION OF DDT IN AMBIENT SOIL SOLUTION OF UPPER SOIL CORES IN OLIN AND CHECK SITE CALCULATED FROM CONCENTRATION VALUES OF SOIL SAMPLES EXCEEDING 1 PPM DDT AND EXPERIMENTALLY DERIVED K VALUES.(1)

DDT(2) IN SOIL CORES	EQUILBRIUM CONC. OF DDT IN SOIL SOLUTION		OCCURRENCE IN SITE
UG/G	UG/ML		%
1.5	0.00031		11.6
3.5	0.00072		4.5
7.5	0.0015		5.7
17.5	0.0036		8.9
37.5	0.0077		7.4
75.0	0.0200		39.3
	$\bar{X}$ 0.02	TOTAL OF SITE	77.4
CHECK SITE			
>1.0	0.00		100

(1) AS IN TABLE 12

(2) AS IN TABLE 12

(3) MAXIMUM ALLOWABLE CONCENTRATION IN COMMUNITY AND NAVIGABLE WATERS ESTABLISHED BY EPA IS 0.001 UG/L OR 0.000001 UG/ML (PPM). REFERENCE: 40 CFR 129.101 (3).

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TABLE 14 - ESTIMATED EQUILBRIUM CONCENTRATION OF DIELDRIN IN AMBIENT SOIL SOLUTION OF UPPER SOIL CORES IN OLIN AND CHECK SITE CALCULATED FROM CONCENTRATION VALUES OF SOIL SAMPLES EXCEEDING 1 PPM DIELDRIN AND EXPERIMENTALLY DERIVED K VALUES.(1)

DIELDRIN(2) IN SOIL CORES		EQUILBRIUM CONC. OF DIELDRIN IN SOIL SOLUTION		OCCURRENCE IN SITE
UG/G		UG/ML		%
1.75		0.03		9.0
3.75		0.06		5.2
6.00		0.10		4.8
	$\bar{X}$	0.06	TOTAL OF SITE	19.0
CHECK SITE				
>1.0		0.00		100.0

(1) AS IN TABLE 12

(2) AS IN TABLE 12

(3) MAXIMUM CONTAMINANT LEVELS OF DIELDRIN IN COMMUNITY AND NAVIGABLE WATERS ESTABLISHED BY EPA IS 0.003 UG/L OR 0.000003 UG/ML. REFERENCES: 40 CFR 129.100 (3).

TABLE 15 - ESTIMATED EQUILBRIUM CONCENTRATIONS OF CHLORDANE IN AMBIENT SOIL SOLUTION OF UPPER SOIL CORES IN OLIN AND CHECK SITE CALCULATED FROM CONCENTRATION VALUES OF SOIL SAMPLES EXCEEDING 1 PPM CHLORDANE AND EXPERIMENTALLY DERIVED K VALUES.(1)

CHLORDANE(2) IN SOIL	EQUILBRIUM CONC. OF CHLORDANE	OCCURRENCE IN SITE
UG/G	UG/ML	%
1.75	0.076	5.2
3.75	0.170	2.6
6.00	0.270	10.8
	$\bar{X}$ 0.20 TOTAL OF SITE	18.6
CHECK SITE		
> 1.0	0.00	100.0

(1) AS IN TABLE 12

(2) AS IN TABLE 12

(3) MAXIMUM CONCENTRATIONS OF CHLORDANE IN COMMUNITY AND NAVIGABLE WATERS ESTABLISHED BY EPA IS 0.003 UG/L OR 0.000003 UG/ML. REFERENCES: 40 CFR 117.3, CFR 53:0110-3.

TABLE 16 - ESTIMATED EQUILBRIUM CONCENTRATIONS OF HEXACHLOROBENZENE IN AMBIENT SOIL SOLUTION OF UPPER SOIL CORES IN OLIN AND CHECK SITE CALCULATED FROM CONCENTRATION VALUE OF SOIL SAMPLES EXCEEDING 1 PPM AND HEXACHLOROBENZENE AND EXPERIMENTALLY DERIVED K VALUES.(1)

HEXACHLOROBENZENE(2) IN SOIL CORES		EQUILBRIUM(3) CONC. OF HEXACHLOROBENZENE IN SOIL SOLUTION		OCCURRENCE IN SITE
UG/G		UG/ML		%
1.5		0.00035		6.0
3.5		0.0008		2.3
7.5		0.0018		1.0
17.5		0.004		1.5
37.5		0.009		2.1
75.0		0.018		8.6
	$\bar{X}$	0.009	TOTAL	21.5
CHECK SITE				
>1.0		0.00		100.0

(1) AS IN TABLE 17

(2) AS IN TABLE 12

(3) MAXIMUM ALLOWABLE CONCENTRATIONS OF HEXACHLOROBENZENE IN COMMUNITY AND NAVIGABLE WATERS ESTABLISHED BY EPA IS 0.000003 UG/ML (PPM).
REFERENCE: 40 CFR 129.100 (3)

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TABLE 17 - ESTIMATED EQUILBRIUM CONCENTRATIONS OF BIPHENYL (PCB) IN AMBIENT SOIL SOLUTION OF UPPER SOIL CORES IN OLIN AND CHECK SITE CALCULATED FROM CONCENTRATION VALUES OF SOIL SAMPLES EXCEEDING 1 PPM BIPHENYL AND EXPERIMENTALLY DERIVED K VALUES.(1)

PCB IN SOIL CORE		EQUILBRIUM CONC.(2) OF PCB IN SOIL SOLUTION		OCCURRENCE IN SITE
UG/G		UG/ML		%
1.5		0.01		5.4
3.5		0.02		14.7
7.5		0.05		14.4
17.5		0.17		16.9
37.5		0.25		7.9
75.0		0.50		23.0
	$\bar{X}$	0.012	TOTAL	82.3
CHECK SITE				
3.5		0.02		12.7
	$\bar{X}$	0.02		

(1) DERIVED K VALUES FROM: CHIOU C.T. 1981 PARTITION COEFFICIENT AND WATER SOLUBILITY IN ENVIRONMENTAL CHEMISTRY, IN HAZARD ASSESSMENT OF CHEMICALS: CURRENT DEVELOPMENT, VOL. 1. EDITORS; J. SAXENA AND F. FISHER, ACADEMIC PRESS, NEW YORK.

(2) AS IN TABLE 12

(3) MAXIMUM CONCENTRATIONS OF PCB IN COMMUNITY AND NAVIGABLE WATERS ESTABLISHED BY EPA IS 0.001 UG/L OR 0.000001 UG/ML (PPM). REFERENCE: 40 CFR 129.105. (4)

TABLE 18 - ESTIMATED EQUILBRIUM CONCENTRATIONS OF HEXACHLOROCYCLOHEXANE IN AMBIENT SOIL SOLUTIONS OF UPPER SOIL CORES IN OLIN AND CHECK SITE CALCULATED FROM CONCENTRATION VALUES OF SOIL SAMPLES EXCEEDING 1 PPM HEXACHLOROCYCLOHEXANE AND EXPERIMENTALLY DERIVED K VALUES.(1)

HEXACHLOROCYCLOHEXANE IN SOIL CORE		EQUILBRIUM CONC. OF HEXACHLOROCYCLOHEXANE IN SOIL SOLUTION		OCCURRENCE IN SITE
UG/G		UG/ML		%
1.75		0.000005		5.2
3.75		0.00009		7.6
6.00		0.0002		7.5
	$\bar{X}$	0.0008	TOTAL OF SITE	20.3
CHECK SITE				
>1.0		0.0		100.0

(1) AS IN TABLE 12

(2) AS IN TABLE 12

(3) MAXIMUM ALLOWABLE CONCENTRATION OF HEXACHLOROCYCLOHEXANE IN COMMUNITY AND NAVIGABLE WATERS ESTABLISHED BY EPA IS 0.004 MG/L (0.004 UG/ML PPM). REFERENCE: 40 CFR 141.12

TABLE 19 - COMPARISON OF SELECT TOXICANT CONCENTRATIONS IN AMBIENT SOIL SOLUTION IN OLIN AND CHECK SITE FOR SOIL SAMPLE CONCENTRATIONS EXCEEDING 1 PPM OF RESPECTIVE TOXICANT.

TOXICANT	MEAN EQUILBRIUM CONC. IN SOIL SOLUTION OVER SITE		EPA LIMIT IN WATER	CONC.(1) RATIOS OLIN/EPA
	CHECK	OLIN		
	PPM		PPM	
TOXAPHENE	0.0	6.04	0.005	1208
DDT	0.0	0.02	0.000001	20,000
DIELDRIN	0.0	0.06	0.000003	20,000
CHLORDANE	0.0	0.20	0.000003	66,666
PCB	0.02	0.012	0.000001	12,000 (CHECK SITE 20,000)
HEXACHLORO-BENZENE	0.0	0.009	0.000003	3,000
HEXACHLORO-CYCLOHEXANE	0.0	0.0008	0.004	0.2

(1) CONCENTRATION RATIO IS MEAN ESTIMATED CONCENTRATION OF TOXICANT CALCULATED IN SOIL SOLUTION OVER OLIN SITE COMPARED TO EPA ALLOWABLE LIMITS.

Section 5 -Assessment of soil contamination of Olin site as of June, 1982.

5.1 Analysis of data in Table 1 (Section 1.3), the field description of soil cores.

Foreign materials varying from glassy grit, stones-concrete to powdered sulfur and lime in the soil profile of the Lake Charles series underlying the mantle of the Olin site was observed in the shallow and deep cores taken in the northern portion of the site encompassing sample locations 1-12. The strong, chemical odors emitted from the cores indicates the presence of volatile organic compounds in amounts that have exceeded the absorptive capacity of the soil and the attenuation of the degrading process. These observations are evidence of past industrial activities involved in the manufacture and disposal of organic compounds. The absence of chemical odors is evident in the cores of the check sites where the odor and appearances of the profile are typical of uncontaminated, fresh Lake Charles clay soil. Soil samples from the southern position of the site (sample locations 15-21) are relatively free of debris and volatile substances with odor indicating that this area had been utilized for plant operations that did not involve the manufacture or disposal of material similar to those in the northern portion of the site. In addition, the soil cores indicate a higher concentration of materials in the area of samples 13 and 17 possibly a disposal site as delineated by the air photographs, Symap, and chemical analysis.

5.2 Analysis of Symap and data in Tables 8-11 (Section 4.1, 4.2, and 4.3)

It is quite obvious from the Symap projections that the soil in the Olin site is contaminated with the respective toxicants at concentrations many times greater than the check sites. Symap also identifies the area of highest contamination as the northern portion of the Olin site in the area of pre-existing plant buildings and manufacturing activities. The soil adjacent to the E. fence and drainage channel also show relatively high levels of the respective toxicants. The compound PCB appears to be ubiguitous in this environment as it is found in the soil over the entire Olin site and the check site as well. This Symap clearly shows the site of the pre-existing buildings and the area of high concentration near the E. fences as single-point source (see CFR No. 40 260:10 for definition) of toxicants over the Olin site.

The data developed for Table 8 estimates the amounts of toxicants discharged into the environs from the manufacturing activities which have accumulated in the upper soil profile to 24" depth during the period of plant operation. The plant had discharged sufficient quantities of the respective toxicants into the environment to raise levels absorbed by the soil to levels exceeding the amounts defined by EPA as hazardous discharge by 2-2000 times. This range identifies only the toxicants retained in the upper layers of the soil at the time of sampling and does not measure the amounts that have moved into the deep soil matrix and through the soil into the ground water during the operation of the Olin plant. Deep soil sample analysis has shown that the toxicants have moved deeper into the profile where quantities 15-85% of the surface amounts are retained (see chemist report-Appendix). A total

of 4641 pounds of toxicants were estimated to be retained in the upper soil depth over the Olin site and only 12.9 pounds in the check site at the time of sampling (Table 8).

Comparision of toxicant concentrations in soil of the check and Olin site are given in Tables 9, 10, and 11. For example, in Table 9, the mean concentration of toxaphene in the Olin site soil is 49.7 ppm and 0.15 ppm in the check site indicating that the toxaphene is 324 times more concentrated over 47% of the Olin site. The toxicant DDT is 94 times (Table 9) more concentrated than the check site over 90% of the Olin site (Table 11). When the mean concentrations of the respective toxicants in the Olin site that exceed 1 ppm are compared to an EPA standard of 1 ppm (see footnote Table 10) the range for all toxicants was 1-48 times greater than the EPA standards (see Tables 10 and 11) over 18% to 82% of the Olin site.

5.3 Analysis of data in Tables 12-19, the concentration of soil toxicants in equilbrium with toxicant in ambient solutions.

The magnitude of soil contamination can also be assessed from the concentration of the respective soil toxicants in equilbrium with toxicant in the ambient soil water. The concentration of toxaphene in the ambient solution in equilbrium with the soil in the upper layer of the profile at different concentrations is given in Table 12. Employing calculations described in Section 4.4, the concentration of toxaphene in the ambient soil solution is estimated at 0.08 ug/ml (ppm). At the highest midpoint level of soil toxaphene, 375 ug/g, the estimated solution concentration is 21.9 ug/ml. The data in Tables 13-18 for the remaining toxicants were generated and analysed in a similar manner. In the case of toxaphene, 46.9% of the Olin site exceeded 1 ppm which con-

tributed a mean concentration of 6.04 ug/ml in the ambient solution. When this value is compared to the maximum allowable concentration of toxaphene in community and navigable water by EPA that is 0.005 ppm (see footnote Table 12), the concentration of toxaphene in ambient soil is 1208 times greater than the EPA allowable limit (See Table 19). The estimated solution concentration and areal distribution for the remaining toxicants are given in Tables 13-18. Since the soil concentration levels of the toxicants in the check sites did not reach the 1.00ppm set by EPA, the ambient solution concentrations were not calculated except for PCB where K_{ow} values at a mid point soil concentration of 3.5 ppm estimates PCB at 0.02 ppm in ambient solution over 12.7% of the check sites. In the Olin site the mean solution concentration of PCB was 0.012 ppm over 28% of that site.

The collation of data from Tables 12-18 and the ratios between toxicant concentration in soil solution and EPA allowable limits in water--are given in Table 19. For each toxicant, except hexachlorohexane, their mean concentration in solution exceeds the EPA allowable limits by a range of 1208 to 66,666.

5.4 Analysis of deep soil samples to assess soil contamination in Olin and check sites.

The following assessment is based on data of sample sites 2, 6A, 13, 17, and 20 presented in Tables A1, A2, and Figure 1 of the chemists report, pp. 30-32 (See Appendix).

The relative toxaphene concentration in the surface (upper) soil samples and the deep samples 2' are given in Table A1. The integrated areas of the chromagraph peaks represent the relative concentration of toxaphene components and other pesticides in the soil extracts. Assigning a relative value of 1.0 to the concentration of the toxaphene components to sample extract 6A-1, the magnitude of soil contamination of the remaining samples is compared to the 6A-1 standard. Sample 6A-1 was chosen as the standard because the peak areas indicated a mean concentration range identified in Table 2. Thus, the concentration of toxaphene components in sample 2-1 relative to the standard is 9.9 while sample 17-1 is only 0.19. The important relationships given in Table A2 and depicted in Figure 1 show the concentration of toxaphene components in the deep soil samples relative to the concentration in the upper soil profile.

Employing a standard of 100% for the upper samples the deeper samples, those under 2 ft., exhibit concentration ranging from 80% to 15% of the upper concentration in soil samples 2, 6A, 13, and 17. The concentration in the deep samples for location 20 was undetectable reflecting the very low concentration in the upper profile (See Table 2 and Table A1). There are several implications in these data:

1. The unusual persistence of the toxicants is manifest by the high concentrations found in the soil profile. Hazardous levels of all

toxicants are still evident 10 years after the plant operations have ceased attesting to the very slow degrading processes operating in the Olin site and the continuous cumulative building of toxicants in the soil during the period of manufacturing activities (1938-72).

2. The slow, downward migration of upper level toxicants in the profile also attests to the persistence of the toxicants and the long-term adverse impact on the quality of ground water.

3. The concentration of toxicants in the deeper profile, although 15% - 80% of the upper concentration still constitutent a hazard, as defined by EPA, in the soil and ground water to biological life and health.

5.5 Summary assessment and concluding statements.

Chemical analysis of randomized acquired soil samples over the Olin and check sites provided the data base for a rigorous assessment of soil contamination.

Symap projection have clearly delineated the location of pre-existed plant buildings and areas of manufacturing activities as single point sources of soil contamination in the Olin site. Existence of a waste disposal area located on the Olin property near the E. fence line and drainage channel was also evident in the Symap projections and independently assessed from distributions - concentration level of soil samples by the team of organic chemists (see report - Appendix).

The actual amounts of select toxicants in the soil profile of the Olin site at the time of sampling exceeds the quantities found on the check site by a factor range of 100-3000. Approximately 72% of the Olin site was contaminated by toxicant exceeding the check values. However, when these amounts are compared to EPA values for quantities termed "hazardous wastes discharge" the amounts calculated for the Olin site range from 2-2000 times greater than the EPA level, attesting to the magnitude of soil contamination at this site (See Table 8). Utilizing a generic level of 1 ppm toxicant in the soil as an EPA limit for organic pesticides which if exceeded constitutes a "hazardous concentration", the concentration of toxicants in soil of the Olin sites exceeds the EPA limit from 0.77 to 48.7 fold over 72% of the site.

Concentrations of specific toxicants in the ambient soil solution in equilbrium with the soil toxicant shows extremely high solute levels

compared to EPA maximum allowable limits in community and navigable waters. The concentration of toxicants in ambient solution over 41% of the Olin site ranges from 0.0008 ppm for hexachlorocyclohexane to 6.04 ppm for toxaphene or a range of 0.2 to 66,666 times the maximum allowable limits set by EPA.

Analysis of deep soil samples show the persistence of the toxicants has exceeded the normal half-life (See Sections 6.1 of Appendix). Presence of toxicants in upper and deeper soil depth at levels that constitute a hazard to biological life and health are evident 10 years after the plant operations had ceased. Concentrations of toxicants in the deep samples range from 15-80% of the surface value, yet these concentration exceed EPA allowable limits for soil and water and therefore constitute a hazardous waste.

Concluding Statements

It is the professional opinion of the principal scientist and consultant to this study that the soil in the Olin site is contaminated with select toxic organic substances at concentrations which are hazardous to biological life and health as defined by EPA. This opinion is based on a rigorous, logical assessment of facts from data of several sources developed during this study.

1. The upper soil profile (12-24") under the mantle over 50% of the Olin sites contain amounts of toxaphene, DDT and metabolites, chlordane, dieldrin, pentachlorobenzene, hexachlorobenzene, and PCB that respectively and in total exceed the EPA limits defined as a hazardous discharge by factors ranging 2-2000 times.
2. The soil concentrations of the respective toxicants listed in (1) above have exceeded the generic maximum limit of 1 ppm (utilized by EPA) over 50% of the Olin site by factors ranging from 0.8 to 48.7 times.
3. Deep soil cores (24" to 72") in select locations demonstrate that 15-85% of the toxicant concentrations in the upper profile layers are found in the deep cores. Concentrations of toxicants in the deep cores exceed the 1 ppm limits set by EPA.
4. We have estimated that the respective toxicants absorbed by the soil had contributed to the equilbrium concentration of toxicants in the ambient soil solution (except for hexachlorocyclohexane) at levels that exceeds the EPA concentration limits for community and

navigable waters by factors ranging from 1208 to 66,666 times.

5. Analysis of deep soil core samples indicate movement of toxicants through the soil profile resulting in toxicant concentrations from 15-85% of the upper soil profile. These levels in the deep profile constitute a hazardous level of toxicants and therefore induce adverse effects on the quality of ground water and present a threat to biological life and health.

6. The persistance of the respective high concentrations of toxicants in soil of the Olin site exceeds the experimental half a life of the respective toxicants and therefore the toxicants have continued to present a hazardous waste in the soil and soil solution 10 years after manufacturing operations had ceased. It is not possible to make a definitive statement as to the length of time these toxicants will remain at hazardous levels in soil of the Olin site. It is suspected however because of the exceptional high levels of toxicants in the soil, the lack of light and reduced level of oxygen beneath the mantle which depresses the degradation process, the toxicants will remain at hazardous levels for an extended period, perhaps 15 years based on the optimum conditions.

7. At the time of sampling, the amounts and concentrations of the respective toxicants in the soil of the Olin site exceeded the levels of identical toxicants in the check

sites by a mean factor of 173 times. Since the check sites are representative samples of the environment with the same ecosystem as the Olin plant site, the large toxicant concentration differences between sites is indicative of previous abnormal adulteration of the soil in the Olin site with the products produced during the manufacturing activities at the Olin site.

8. Symap projections coupled with deep soil sample analysis delineate the areal and depth limits of the soil contamination in the Olin site.

C.B.I. CLAIM WAIVED
- 40 C.F.R. §2.205~~(d)(1)~~ -
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Section 6 - Appendix

6.1 Calculations employed to generate data for Tables 8-19 of the Olin report.

6.2 Chemical analysis of soil samples from Houston site.

Section 6.1 Calculations employed to generate data for Tables 8-19 of the Olin Report.

Table 8

1. Area of Olin site 8,580 acres, (373,750 sq. ft.).
2. Estimated volume of upper soil cores:

   373,750 sq. ft. x 1 = 373,750 cu. ft.

3. Wt. of soil volume: 373,750 x 1.30 (bulk density)

   x 60.2#(cu. ft. water) = 30,124,250#

4. Estimated pounds of respective toxicants in Olin site based on Symap projections:

$$\sum \left(\text{Number of occurrances for each value No.} \div 2{,}166 \times 30{,}124{,}250 \div 1 \times 10^6 \times \text{Midpoint concentration.} \right)$$

5. Estimated pounds of respective toxicants in check sites based on Symap projections:

$$\left(\text{330 occurrances for one value No.} \right) \div 2{,}166 \times 30{,}124{,}250 \div 1 \times 10^6 \times \text{Mid-point Concentration}$$

Table 9 Estimated mean concentration of respective toxicants in soil of Olin and check site

$$\sum \left(\text{Number of occurrances for each value No.} \times \text{Midpoint conc.} \right) \div 2{,}166$$

Table 10 Estimated percentage of sites contaminated with respective toxicants at concentrations exceeding 1 ppm - from Symap projections;

$$\frac{\text{Olin site}}{\left(\text{number of occurrance for each value No.} > 1 \text{ ppm} \right) \div > 1 \text{ ppm total occurrances}}$$

check site - single site

162 × Value No. > 1 ppm ÷ Total occurrances > 1 ppm

check site - two sites

(site 1) + (site 2) ÷ 2

Table 11 Estimated mean areal distribution of concentrations of toxicants in Olin and check sites compared

$$\left(\begin{array}{l}\text{Number of occurrances of each}\\ \text{value No.} > \text{check values}\end{array}\right) \div \begin{array}{l}\text{total No. occurrances}\\ > \text{check values}\end{array}$$

$$\left(\begin{array}{l}\text{Number of occurrances of}\\ \text{each value No.} > \text{check value}\end{array} \times \begin{array}{c}\text{Midpoint}\\ \text{conc.}\end{array}\right) \div \begin{array}{l}\text{total of occurrances}\\ \text{check values}\end{array}$$

Table 12-18 Estimated concentrations of toxicants in ambient soil solutions of Olin and check sites. From Symap projections and K_{ow} coefficients for all toxicants at soil concentrations exceeding 1 ppm.

1. Log K_{oc} = 1.019 - K_{ow} - 0.18 (See Section 4.4)

   K_{oc} = Equilbrium constant based on pesticide retention by organic matter in soil.

   K_{ow} = Octanal/water partition coefficient for specific toxicant (from literature).

2. K_{oc} = $\dfrac{\text{ug/g absorbed/g of organic carbon (O.C.)}}{\text{ug/ml of solution}}$

3. Lake Charles Clay soil, upper profile, 2.5% O.M.

   or $\frac{2.5}{2}$ = 1.4% O.C. organic carbon

   2 conversion factor

4. $\frac{1.0g}{.014}$ soil = .014g O.C./g soil

5. Equilbrium conc. of specific toxicant in solution for each value number exceeding 1.0 ppm becomes:

$$\text{ug/ml solution} = \frac{\text{ug/g soil}}{.014} \; / \; K_{oc}$$

6. Mean equilbrium concentration for specific toxicant:

$$\left(\begin{array}{l} \text{ug/ml solution for} \\ \text{each value No. 1 ppm} \end{array} \times \text{No. of occurrances} \right) \div \text{total No. of occurances} > 1 \text{ ppm}$$

Table 19 Comparision of solution concentrations of respective toxicants and EPA limits.

$\bar{x}$ conc. in site $\div$ EPA conc. limits

Persistence of select organochlorine insecticides in soil[1]

Chemical	Half-life (years)	Time for[2] 95% dissappearance (years)
Chlordane	1.0	4
DDT	2.8	10
Dieldrin	2.5	8
Toxaphene	0.8	3.5

(1)Data from: Edwards, C.A. 1981 In Persistent pesticides in the environment, 2nd Ed. CRC Press, Boca Raton, Florida.

(2)Data based on silt loam soil planted to annual crops and cultivated each year.

Section 6.2

Chemical Analyses of Soil Samples From Houston Study Site

Prepared for:

Pollution Assessors
Houston, Texas

By:

Dr. E. Atlas

In Consultation With:

Dr. C. S. Giam

Table of Contents

Note: The analyses and data interpretation presented in this report are the sole responsibility of the author. The report is based on many years of experience by the author as a Research Scientist in the field of Organic Analyses and on consultation with Dr. C. S. Giam, a recognized expert on Environmental Chemistry. Though the author is an employee of the Texas A&M Research Foundation, neither the Research Foundation nor the Texas A&M University System reviewed or endorses the contents of this report.

PART I.

Non-Technical Summary

Introduction

This report describes the results of chemical analyses of soil samples submitted by Dr. Eugene Brams of Pollution Assessors from a site in Houston, Texas.

The objective of the study was to determine the concentration of selected chlorinated hydrocarbons (e.g. pesticides) at the study site in Houston. Selected compounds include toxaphene and DDT (figure 1.), as well as HCB, HCH, chlordane and PCB.

Methods

Details of the methodology are presented in the technical section in part two of this report. Briefly, soil samples collected at the site were subsampled and stored frozen until analysis. The organic compounds were extracted from the soil using suitable organic solvents. Separation of the complex mixture of compounds in the extract was carried out by adsorption chromatography followed by capillary gas chromatography.

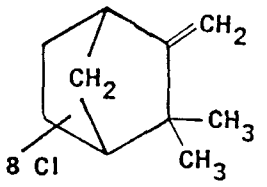
Results and Discussion

The data (Tables 1 - 4; Part II) show that several of the sites have relatively high levels of DDT and toxaphene, as well as hexachlorobenzene, hexachlorocyclohexane, chlordane, and polychlorobiphenyls. The highest concentrations were found at sites 2, 3, 6A, 10, 11, 13 and 17. The localized high concentrations of these chemicals at these sites is consistent with the suggestion that there had been previous industrial activity at the sites, e.g. manufacture, storage, spillage, etc., rather than general background levels of pollution.

Figure 1.

Chemical Structure of Major Chlorinated Pesticides

Toxaphene



DDT

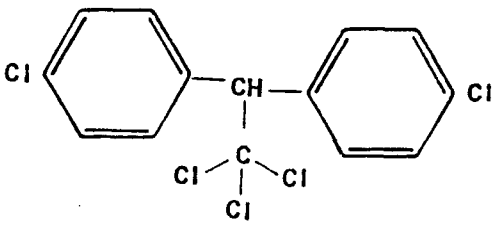
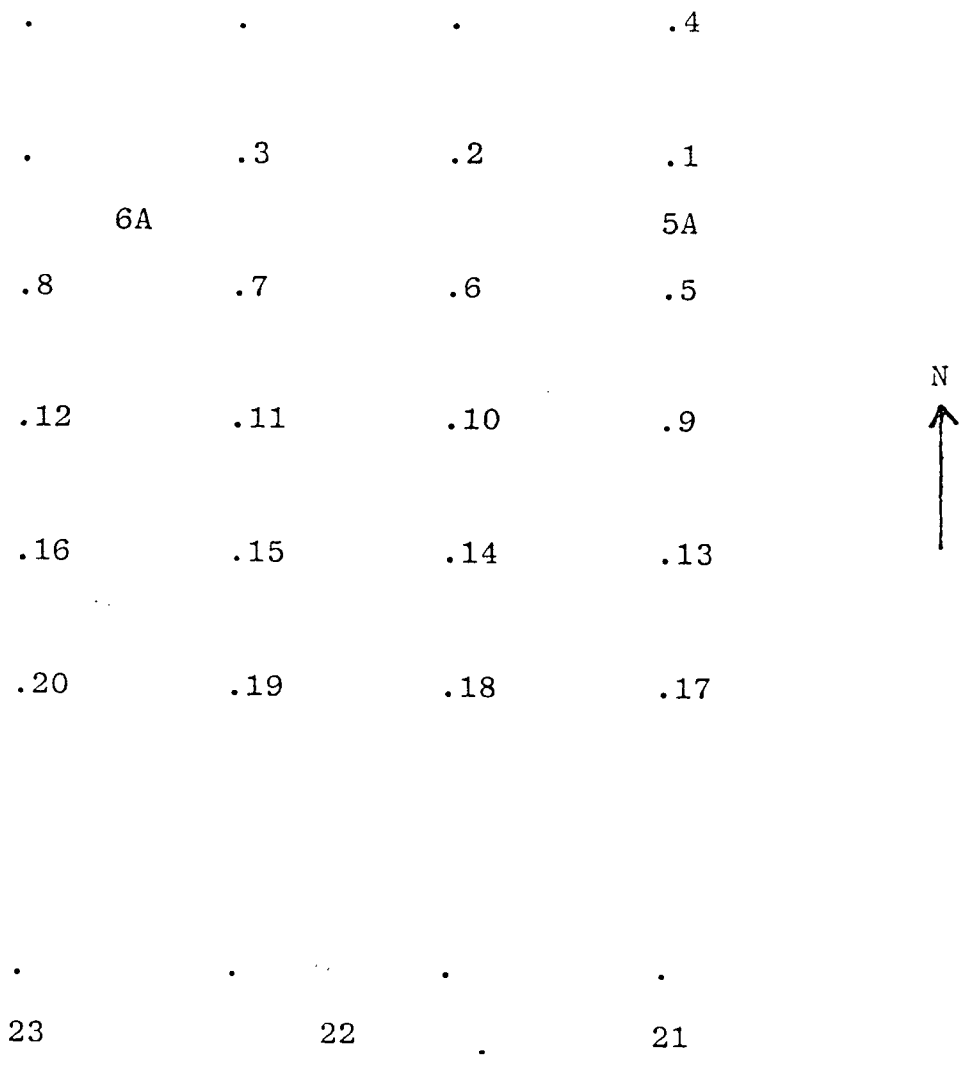


Figure 2.

Approximate relative locations of sampled sites.



PART II.

TECHNICAL SUMMARY

Technical Summary

Introduction

This section of the report will discuss in more detail the methods and results of analyses for the set of soil samples from the Houston study site.

Methods

1) Sampling. Sampling was performed by Brown and Associates using a coring technique. The core sections were sub-sampled using solvent-rinsed metal tools. The soil samples were placed in pre-fired (>500°C) mason jars with aluminum lined caps and were kept frozen until analysis. This procedure minimized any background contamination from sample handling techniques.

2) Extraction. Approximately 50 gram (thawed) samples were weighed into 300 ml round-bottom flasks. Large clumps were physically broken-up using a clean spatula. The sample was refluxed over a steam bath in 100 ml of a 20% acetone: acetonitrile (v/v) mixture for two hours. After cooling, the sample was filtered and rinsed two times with 50 ml of acetonitrile. The filtrate was diluted with 700 ml of 5% NaCl. The diluted filtrate was extracted 3 times with 20% methylene chloride: petroleum ether and concentrated to ~25ml and dried with sodium sulfate in preparation for column chromatography.

3) Column chromatography. Chromatographic separation was performed on a 13 g 1.25% deactivated Florisil column. A 5-ml aliquot of sample extract was placed on the column and eluted with 50 ml petroleum ether (fraction 1) and 50 ml 5% diethyl ether: petroleum ether (v/v) (fraction 2). These fractions were adjusted to appropriate volumes for subsequent gas chromatographic analysis.

4) Gas-chromatography. The samples were analyzed on a Hewlett-Packard 5880 gas chromatograph utilizing a ^{63}Ni electron capture detector. The column was a 30-m DB-1 fused silica column (0.25 mm i.d.), hydrogen was the carrier gas (28 psi). The injector and detector were operated at 225° and 325°C, respectively. The oven program was: 100°C (1 min.), 10°/min. to 130° (hold: 1 min.), 5°/min. to 270° (hold: 5 min.). Peak height, areas, and retention times were recorded and calculated with an electronic integrator. Authentic pesticide standards were used for calibration of the instrument.

Note:

The analytical methods described here were based on published procedures and also on protocols developed independently over many years by the Environmental Chemistry Group under the direction of Professor C. S. Giam, (see reference list). The basic methodology has been validated by numerous internal checks and external inter-laboratory comparisons. The analyses reported here were performed by or under the direct supervision of Dr. E. Atlas, a Senior Research Scientist, with Professor Giam's Group. It is emphasized that neither the Texas A&M Research Foundation nor the Texas A&M

University System reviewed or endorsed the contents of this report. Appropriate literature citations are attached.

Results

The results of the analyses are given in Table 1-4. GC/MS analyses of selected samples confirmed the presence of toxaphene, DDT compounds and other chlorinated compounds in the samples. Additional confirmation was provided by alkaline hydrolysis of the sample extracts. Blanks analyzed along with the samples showed negligible background contamination. Chromatograms of blanks were routinely clean which demonstrated the cleanliness of the laboratory procedures used in this study. Furthermore, soil samples with only trace quantities of contaminants demonstrated that the sampling procedure did not introduce artifacts into the samples prior to analysis. For example, compare the chromatograms of site 15-1 (Fig. 3) and 2-1 (Fig. 4). Even though the extract from site 15 was concentrated over 5000 times more than that from site 2 only traces of compounds are seen in the chromatogram. Excellent recovery of toxaphene, DDT and other pesticides was found for spiked samples analyzed with the normal samples. Sample number designations were those supplied by Brown and Associates (1982). Relative positions (approximate) of the sample locations is given in Figure 2.

Table 1.

Toxaphene concentration (ug/kg) in soil samples from study site.

Sample Designation	Toxaphene Concentration
1-1	1080
2-1	701000
3-1	421000
3-2	342000
4-1	<5
5-1	95
5A-1	<7
6-1	<4
6A-1	71100
7-1	126
8-1	<6
9-1	<5
10-1	7000
11-1	3110
12-1	<4
13-1	27000
14-1	<2
15-1	<5
16-1	<7
17-1	13400
18-1	1560
19-1	<4
20-1	<4
21-1	<4
22-1	40
23-1	7
C1-1	164
C2-1	156

Table 2.

Concentrations of DDT and metabolites (ug/kg) in soil samples from study site.

Sample Designation	DDE*	DDD*	DDT*	ΣDDT**
1-1	105	453	248	806
2-1	8000	11100	69800	88900
3-1	17200	36700	22600	76500
3-2	427	17100	15600	33100
4-1	<1	<1	12	12
5-1	<1	<1	35	35
5A-1	1	<1	7	8
6-1	55	40	14	109
6A-1	309	30400	3326	33762
7-1	488	173	39	700
8-1	3	<1	63	66
9-1	19	9	9	37
10-1	1500	3	13600	15100
11-1	1470	1686	616	3769
12-1	<3	<1	9	9
13-1	21300	5930	3470	30700
14-1	783	12200	5100	18100
15-1	<2	<1	10	10
16-1	7	4	34	45
17-1	7104	402	5960	13500
18-1	390	419	1080	1880
19-1	9	24	8	41
20-1	<1	<1	5	5
21-1	4	4	11	19
22-1	79	127	7	206
23-1	12	3	46	61
C1-1	2	<1	688	690
C2-1	126	<1	24	150

* includes both o,p and p,p' isomers

**ΣDDT = DDE + DDD + DDT

Table 3.

Concentrations of selected chlorinated hydrocarbon insecticides (ug/kg) in soil samples from study site.

Sample Designation	Hexachlorocyclohexane	Chlordane	Dieldrin
1-1	3230	122	18
2-1	11100	10800	4260
3-1	5600	10700	2190
3-2	4180	3041	2471
4-1	166	1	<1
5-1	6	<1	<1
5A-1	55	1	<1
6-1	<1	3	<1
6A-1	2440	10690	814
7-1	12	65	<1
8-1	82	<1	<1
9-1	32	1	<1
10-1	147	485	310
11-1	120	765	36
12-1	<2	<1	<1
13-1	641	2430	1080
14-1	<2	474	185
15-1	5	<1	<1
16-1	7520	<1	<1
17-1	361	633	490
18-1	5	215	22
19-1	<2	6	2
20-1	<2	<1	<1
21-1	<2	1	<1
22-1	<2	56	31
23-1	<2	18	10
C1-1	2	10	20
C2-1	<2	<1	<1

Table 4.

Concentration of chlorinated benzenes and chlorinated biphenyls (PCB) (ug/kg) in soil samples from study site.

Sample Designation	Pentachlorobenzene	Hexachlorobenzene	PCB*
1-1	8	63	1
2-1	2560	70500	10700
3-1	2930	12400	41300
3-2	--	1680	2080
4-1	<1	<1	27
5-1	<1	<1	<1
5A-1	<1	7	<2
6-1	<1	<1	<2
6A-1	8	81	175
7-1	<1	34	8490
8-1	<1	<1	<1
9-1	<1	<1	<1
10-1	20	86	51
11-1	20	43	16800
12-1	<1	<2	4
13-1	183	212	176
14-1	53	153	2870
15-1	<1	<1	<1
16-1	5	<1	273
17-1	64	79	393
18-1	4	13	174
19-1	<1	1	<1
20-1	<1	<1	5
21-1	<1	<1	<1
22-1	3	<3	1170
23-1	<1	5	20
C1-1	<1	4	7
C2-1	<1	<2	2580

*Calculated as the sum of Aroclor 1254 and Aroclor 1260.

Discussion

The soil samples from the study site contained a complex variety of chlorinated hydrocarbons contaminants with a concentration range of over five orders of magnitude. Also, there were often distinct differences in the gas chromatographic "fingerprint" from area to area throughout the study site. Some of these differences are illustrated in Figures 3 to 9. These figures are electron capture chromatograms of representative sample extracts and authentic standards. (Note: Because of the large concentration differences involved and to allow a better comparison of chromatograms, a numerical figure is provided with each chromatogram to indicate the relative degree of dilution of the sample extract. Thus, a small number indicates a relatively small sample dilution (e.g. figure 3); a large number (figure 4) indicates that the sample required considerable dilution because of high concentration of contaminants.) The electron capture detector is most sensitive to halogenated compounds and is fairly selective in its response to organic compounds. Other classes of compounds, such as polynuclear aromatic hydrocarbons, will not be measured with the electron capture technique. Thus, the analyses reported here do not reflect a comprehensive survey of all classes of organic contaminants potentially present in the soil samples. Furthermore, only those electron-capture compounds which could be identified with authentic standards are reported here.

Based on information from the gas chromatographic analyses, a brief summary is given for each sample site:

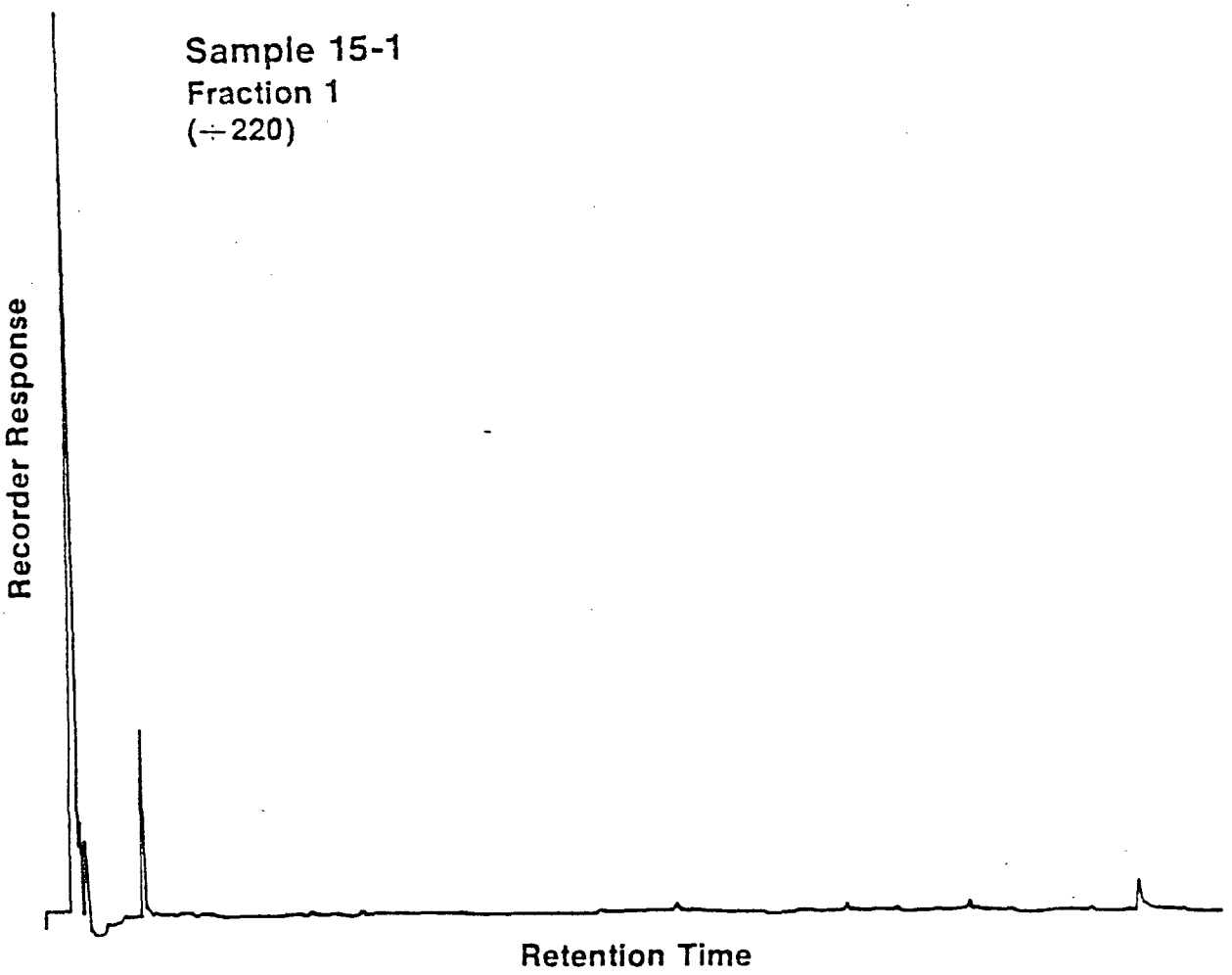


Figure 3.

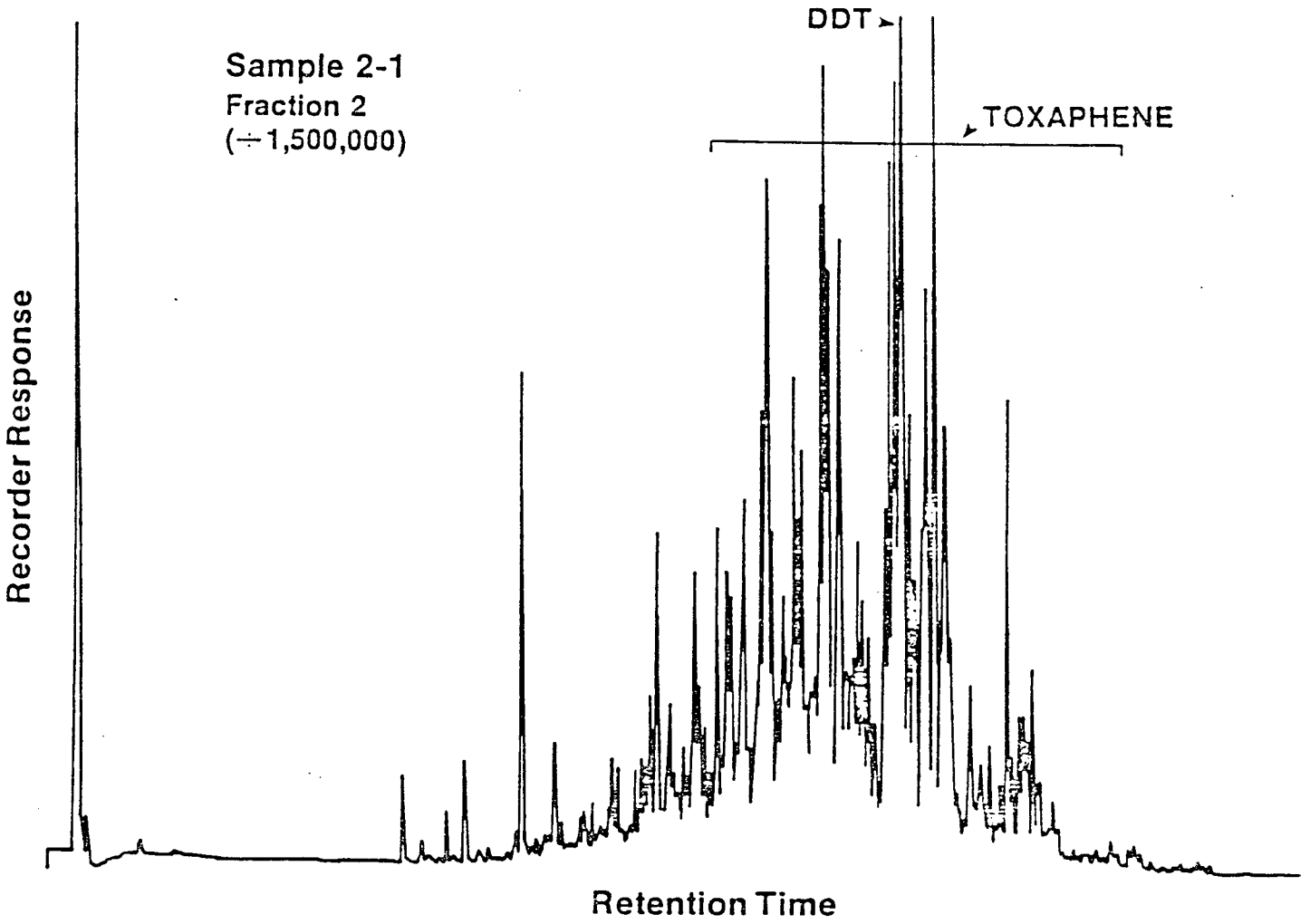


Figure 4

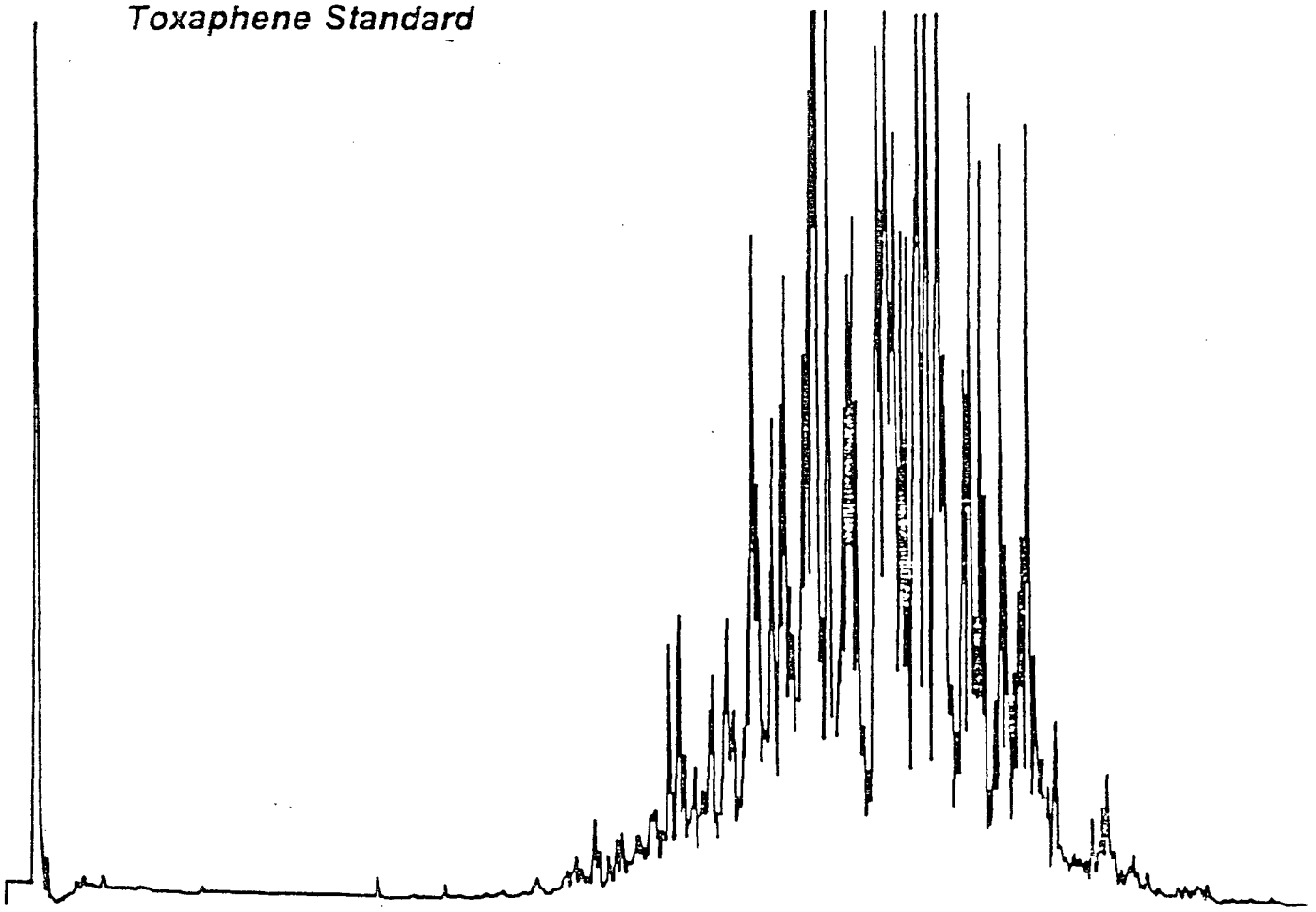


Figure 5

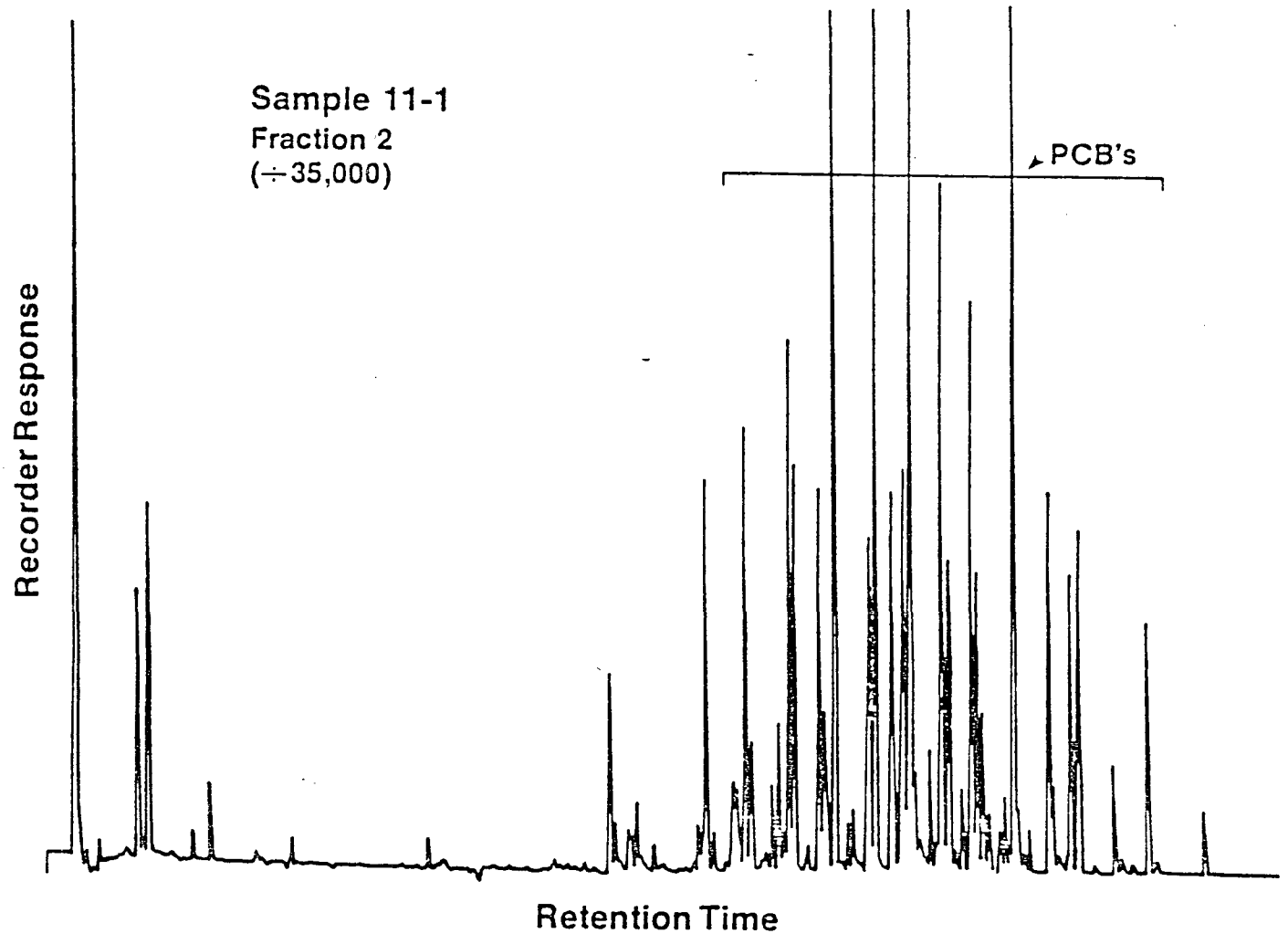


Figure 6

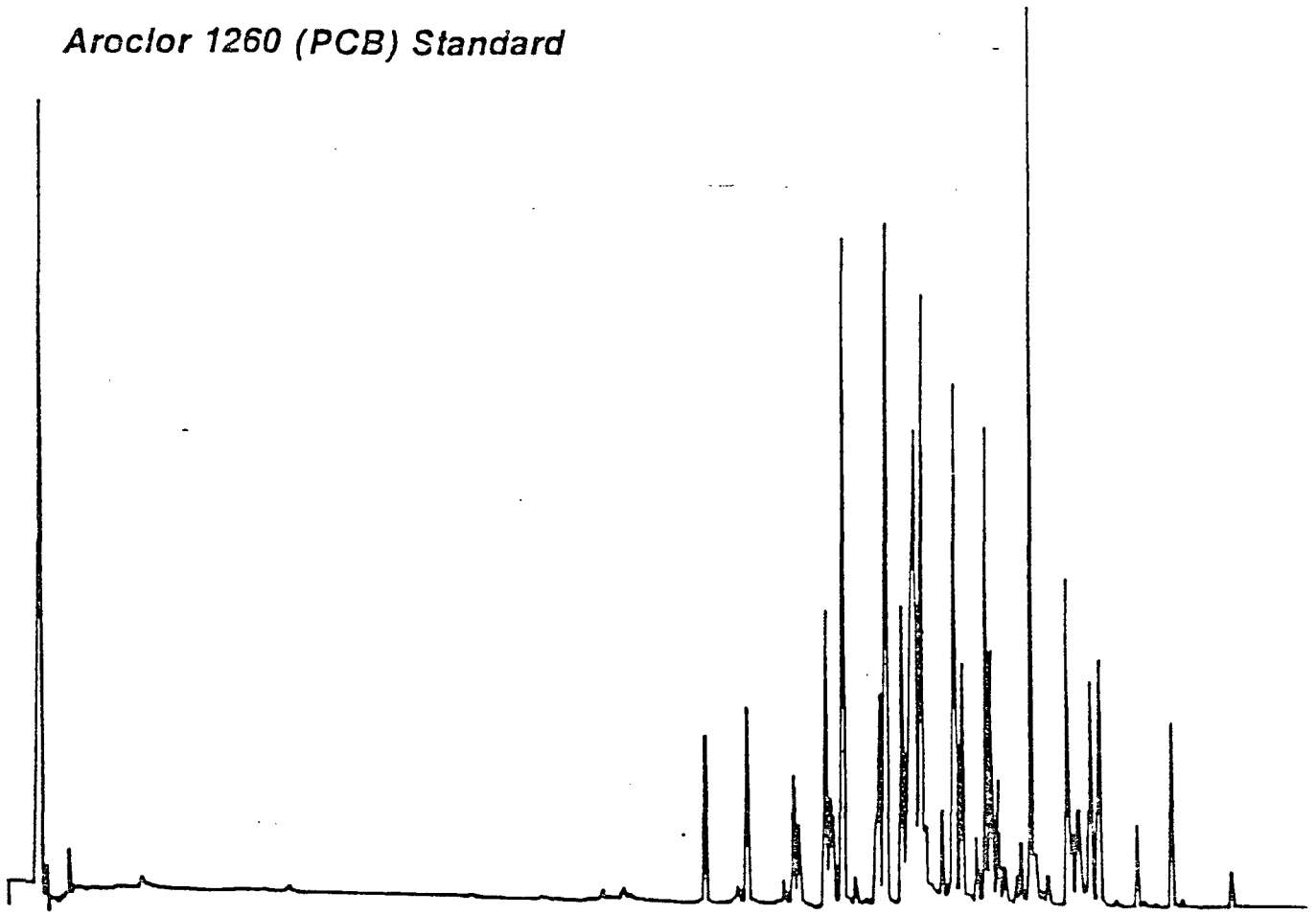


Figure 7

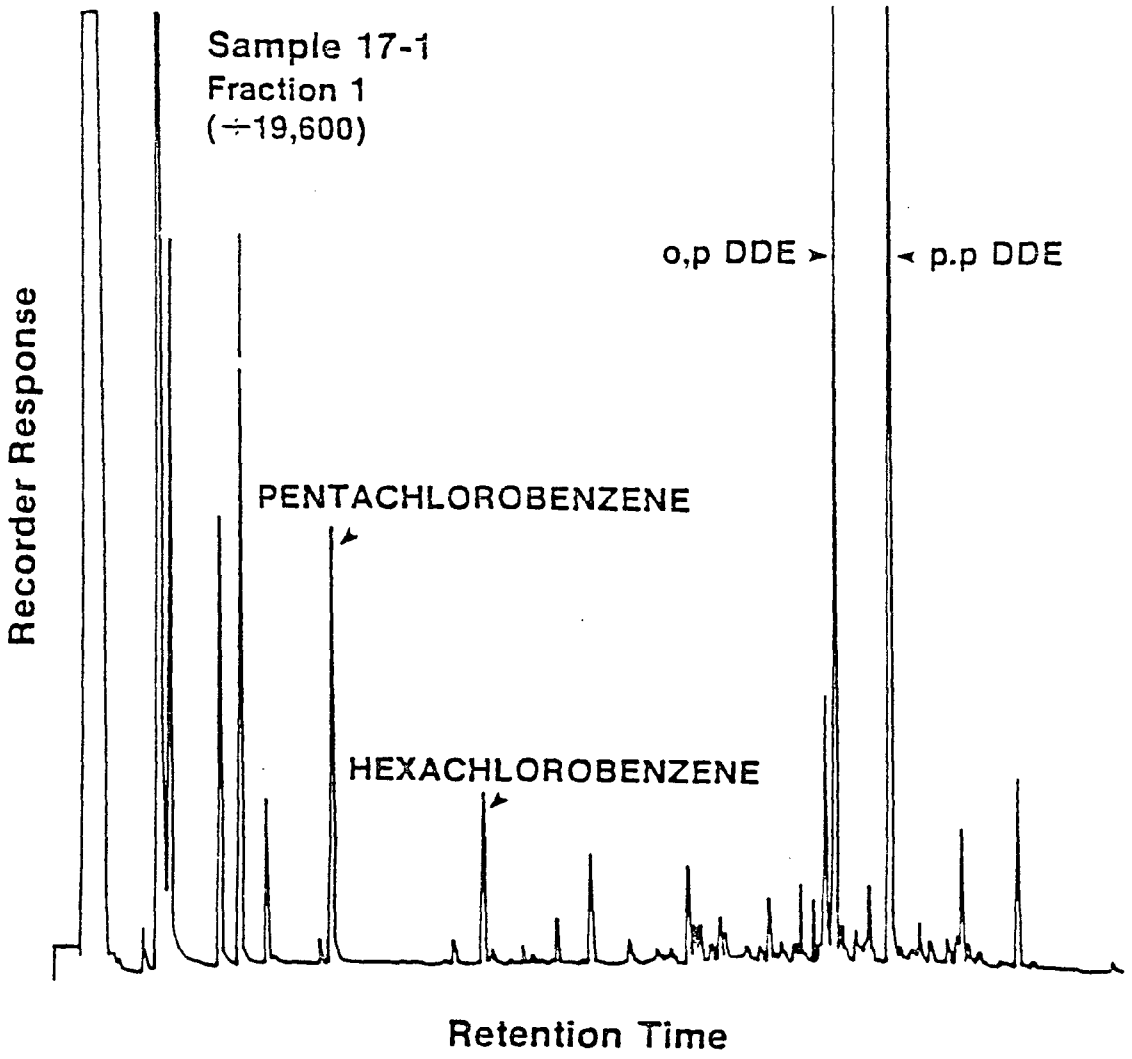


Figure 8

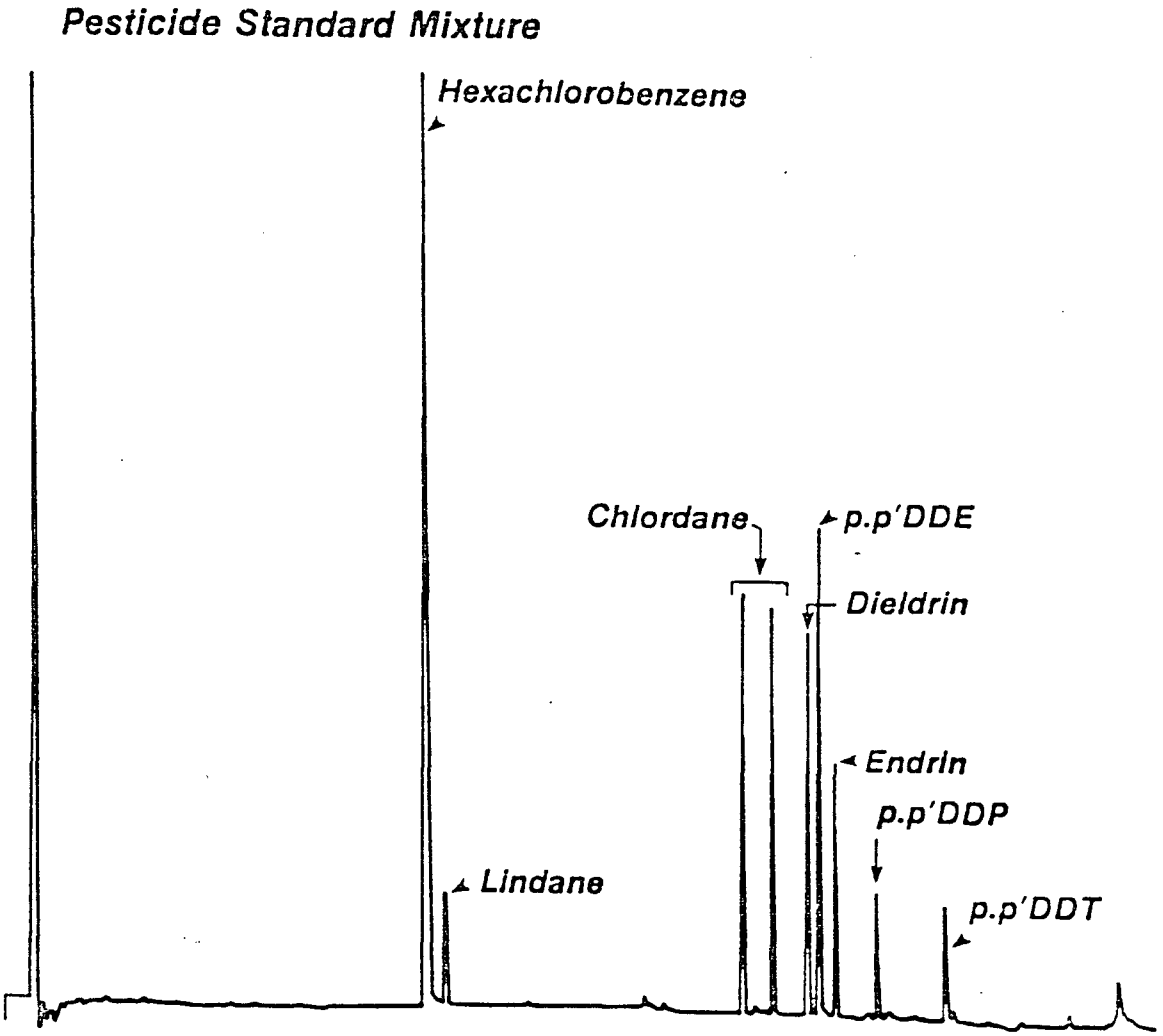


Figure 9

Site 1.) Moderate levels of contaminants; including some unidentified early eluting components. Unknown compound at 11.47 minute retention time (RT).

Site 2.) Heavily contaminated with toxaphene, DDT's and other chlorinated compounds. Unknown at 11.47 minute RT.

Site 3.) Both surface and deep samples show a high degree of contamination by toxaphene, DDT, and other compounds. Unknown at 11.47 minute RT.

Site 4.) Relatively clean site; some hexachlorocyclohexanes (HCH).

Site 5.) Relatively clean site. Unknown at 14.15 minute RT.

Site 5A-1) Similar to Site 5.

Site 6. Relatively clean site. Unknown at 14.15 minute and 14.15 minute RT.

Site 6A-1) Relatively contaminated site; similar to Site 2, and 3. Unknown at 11.47 minute RT.

Site 7.) High levels of PCB.

Site 8.) Relatively clean site; some HCH.

Site 9.) Similar to Site 8.

Site 10.) Relatively contaminated by toxaphene and DDT. Unknown at 11.47 minute and 10.1 minute RT.

Site 11.) High levels of PCB; otherwise similar to Site 10. Unknown at 11.47 minute RT.

Site 12.) Relatively clean site.

Site 13.) DDT and toxaphene contamination; other components relatively high. Unknown at 11.47 minute RT.

Site 14.) Mostly DDT contamination. Unknown at 11.47 minute RT.

Site 15.) Relatively clean site.

Site 16.) Relatively high levels of HCH; some unidentified early eluting compounds.

Site 17.) Moderately high contamination by DDT, toxaphene and other compounds. Unknown at 10.08 minute and 11.47 minute RT.

Site 18.) Moderate contamination by DDT and toxaphene. Unknown at 11.47 minute RT.

Site 19.) Relatively clean site. Unknown at 11.47 minute RT.

Site 20.) Relatively clean site. Unknown at 14.1 minute RT.

Site 21.) Relatively clean site.

Site 22.) Some PCB contamination; otherwise relatively clean site.

Site 23.) Relatively clean site.

Control) Control sites C1 and C2 are relatively clean sites, though C2 shows moderate contamination by PCB.

In general, the area most contaminated with toxaphene and DDT is found in the northern section of the study site (Samples 1, 2, 3, 6A). A second area of contaminated soil is located on the eastern edge of the site around sample areas 13 and 17. Also, high levels of PCB are located in the adjacent sites 7 and 11.

The samples contaminated with toxaphene and DDT are, in general, three to five orders of magnitude higher than other samples within the study area and compared to the control site. These very high localized concentrations of chlorinated compounds are consistent with the suggestion that their source is from prior industrial activity, e.g. manufacture, use, spillage, etc., at specific locations on the site rather than from generalized pollution from the surrounding area.

One other notable feature of the soil extracts was the common appearance of an unidentified peak at 11.47 minutes retention time. The general occurrence (not-quantitative) of this compound is mapped in figure 10. It was a major peak in some of the gas chromatograms. Preliminary tests identify the compound as a chlorinated compound, but its identity cannot be established without further testing.

The distribution of this compound is similar to the areas of high concentration of toxaphene (figure 11).

Figure 10.

General distribution of unknown chlorinated compound (RT=11.47)

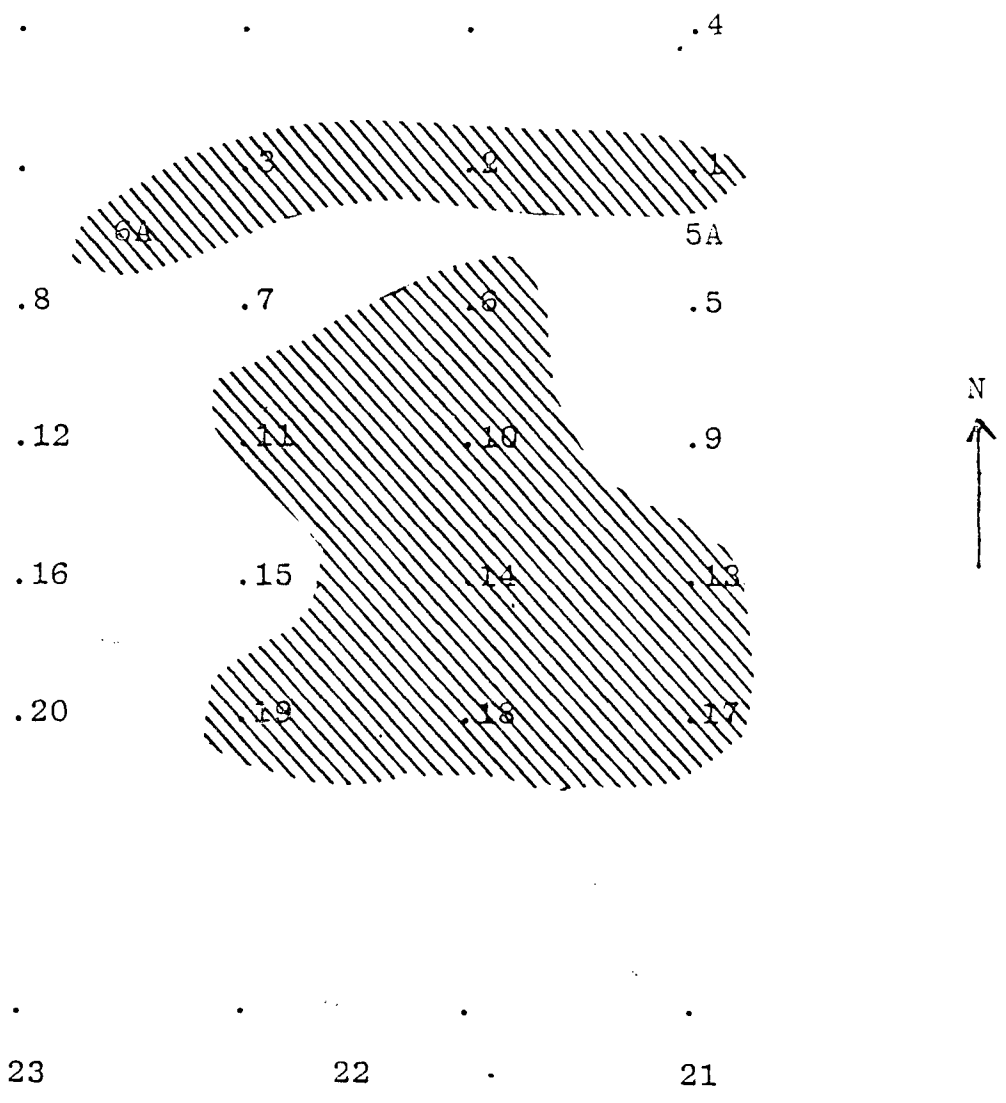
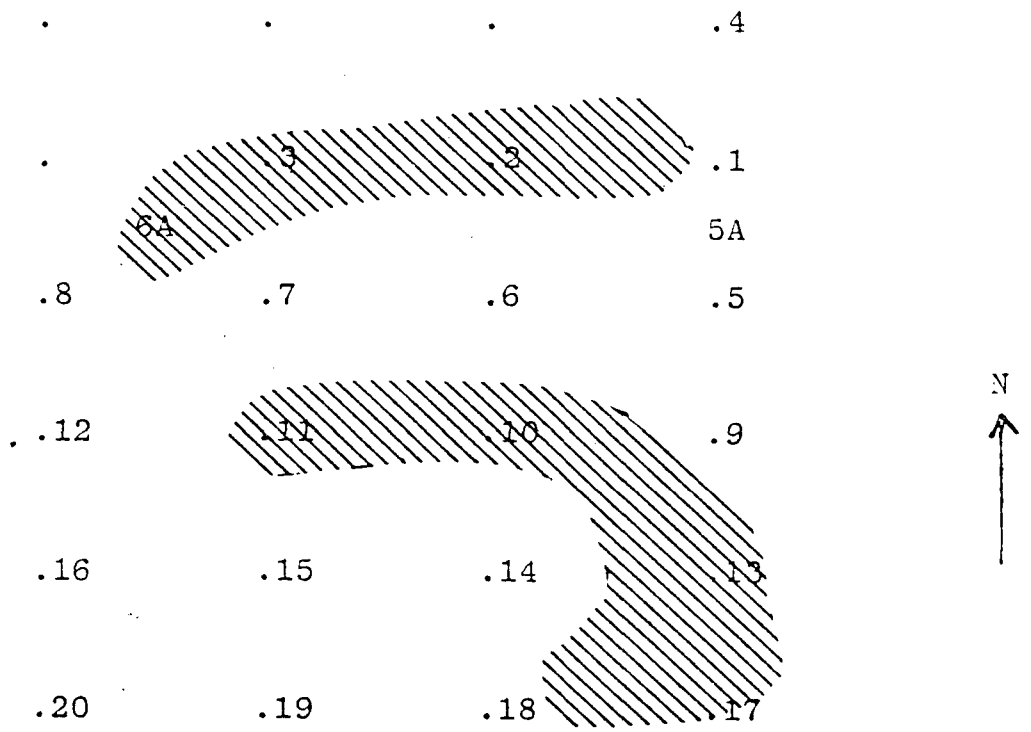


Figure 11.

General distribution of high toxaphene concentrations in soil.



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ADDENDUM:

COMPARISON OF SURFACE AND DEEP SOIL SAMPLES:

Introduction

Chemical analysis of soil from two depths of the same core sample (#3) revealed high concentrations of toxaphene in the deep (2-4') soil layers compared to the surface (0-2') layer. The deep section contained approximately 80% of the concentration of toxaphene measured in the top layer. Pollution Assessors, Inc. has requested examination of additional deep soil samples to determine the extent of penetration of chemicals at other sites in the study area. The samples chosen for re-examination are listed below: (See Figure 2 for locations.)

Sample Designation	Approximate Depth in Core
2-1	0-2'
2-2	2-4'
2-3	4-5'
2-4	5-7'
6A-1	0-2'
6A-2	2-4'
13-1	0-2'
13-2	2-4'
17-1	0-2'
17-2	2-4'
20-1	0-2'
20-2	2-4'

Analysis

For the purposes of the comparison, 1 g soil samples were extracted with methanol and petroleum ether and the resultant extract was analyzed by fused silica capillary gas chromatography using electron capture detectors (identical to analyses described earlier). As in the earlier detailed analyses, the main components of the extracts were toxaphene, DDT components and the unknown compound at retention time of 11.5 minutes.

Results and Discussion

To examine the extent of penetration of chemicals into the deep samples, total integrated peak areas from the chromatograms of the surface and deep sample were compared for each soil core. Because of the predominance of toxaphene components in the soil extracts, this comparison is basically a comparison of the relative toxaphene concentrations in the surface and deeper samples. (See Table A1). The results are shown in Figures A1 and in Table A2.

Table A1

Comparison of surface toxaphene concentrations (Table 1) determined on 50g sub-samples and total integrated peak areas measured on 1g sub-samples (areas and concentrations normalized to site 6A-1).

Sample Designation	Relative Peak Areas	Relative Toxaphene Concentration
2-1	12.3	9.9
6A-1	1.0	1.0
13-1	0.35	0.38
17-1	0.19	0.19
20-1	b.d.*	b.d.*

*b.d. = below detection

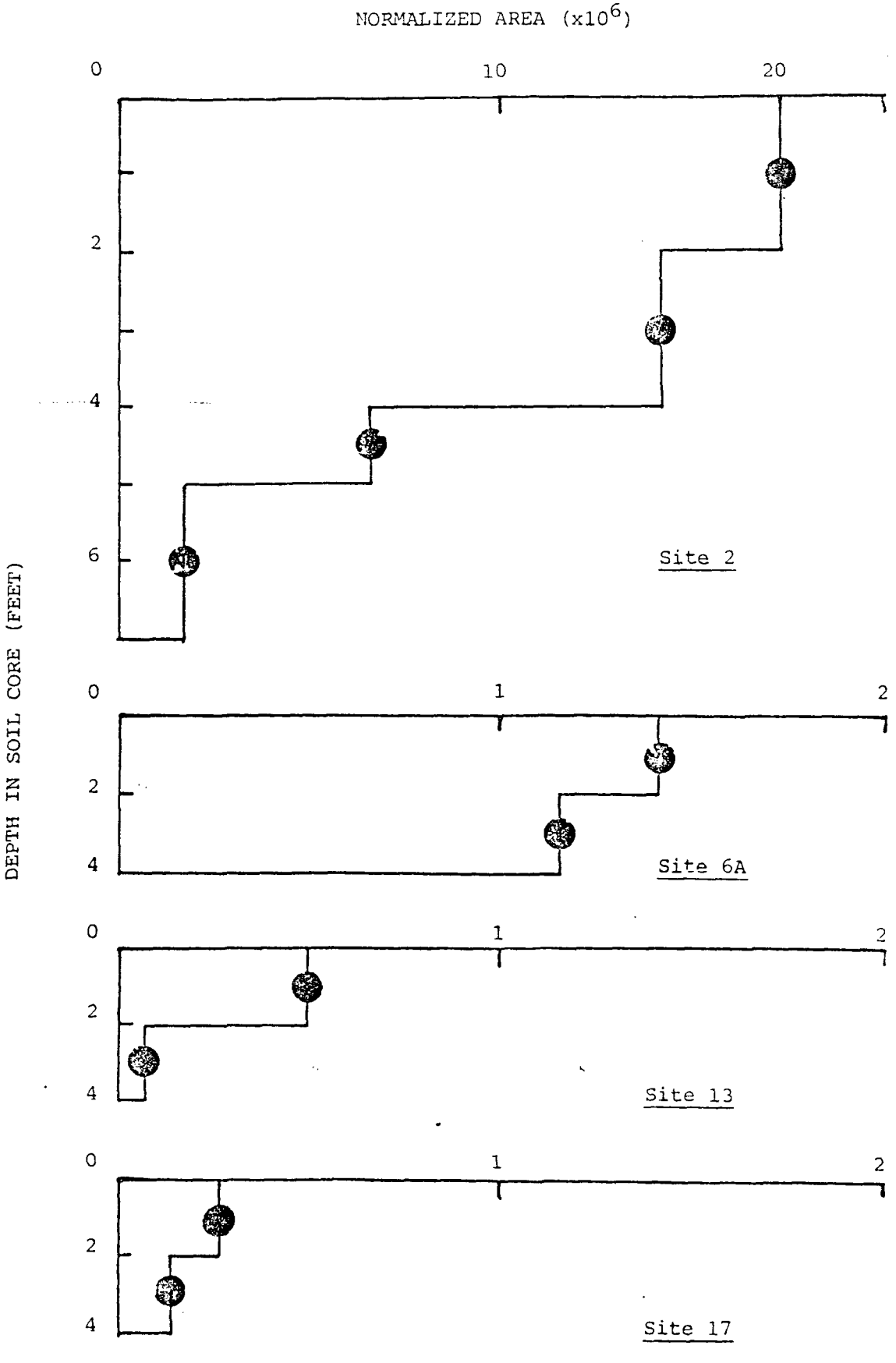
Table A2

Relative concentration of chlorinated chemicals* of surface and deep soil samples.

Sample	Depth	Total** Area x10^6	% of Surface
2.1	0.2'	17.5	100
2.2	2-4'	14.2	81
2-3	4-5'	6.6	38
2-4	5-7'	1.67	9
6A-1	0-2'	1.42	100
-2	2-4'	1.16	82
13-1	0-2'	0.50	100
-2	2-4'	0.08	15
17-1	0-2'	0.28	100
-2	2-4'	0.14	50
20-1	0-2'	<.001	-
-2	2-4'	<.001	-

*Electron capture sensitive components (primarily toxaphene).

**Normalized to 1g soil; 1µl injection/10 ml sample extract.



The data here shows that at any given site there is measurable and significant penetration of toxaphene and other chemical compounds below the 0-2' surface soil layers. A range of 15- 82% of the compounds in the surface layer are found in the adjacent 2-4' depth zone in the soil core. Deeper soil samples at site 2 (up to 7') show generally decreasing levels of chlorinated compounds with increasing depth in the soil core.

As was found in the detailed analyses of the surface soil samples, site #2 contains the highest concentration of chemical contaminants compared to the other sites tested. In fact, the deep sample (5-7') at site #2 showed a comparable or greater level of contamination compared to the other surface samples tested. The clean surface and subsurface soil samples at site #20 demonstrated that there was not significant subsurface mobilization of chemical contaminants to the southwest quadrant of the study site, at least above the 4' soil level.

SUMMARY:

Sub-surface soil samples (2-4') at the Houston study site showed a significant fraction of the chemical compounds found in the surface layer. The range was from 15-82%.

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